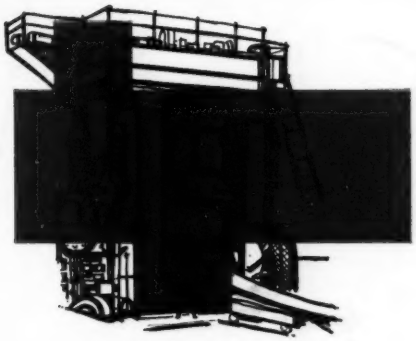
Engineering Materials and Design

TYPICAL METAL FATIGUE FAILURE



An Introduction to the problems of metal fatigue

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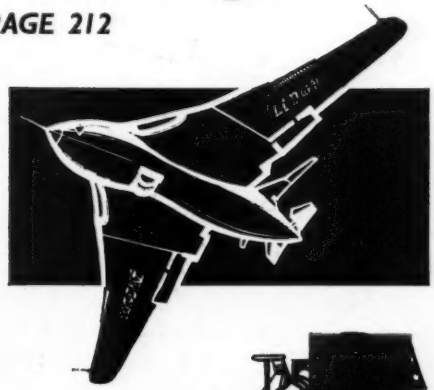

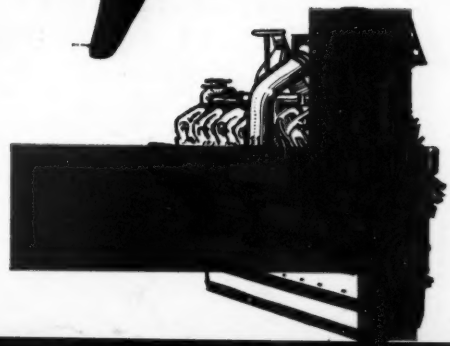

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COVER: The left-hand illustration shows the underside of a flake spalled out of a large steel roll. (Photograph by courtesy of The United Steel Companies Ltd.)

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ISSUE AT A GLANCE

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Describing the nature of fatigue failure, and the factors affecting fatigue strength.
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Dealing mainly with a special technique for the production of coils to a predetermined size.
By **W. Duckett**

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INTRODUCTION AU PROBLEME DE LA FATIGUE DES METAUX

par G. M. Astles page 212

L'auteur traite de la nature des accidents dûs à la fatigue des métaux, des méthodes d'essai que l'on emploie pour établir l'indice de fatigue des matériaux, des facteurs qui influencent la résistance à la fatigue, des théories sur le mécanisme de base de la fatigue et de certaines méthodes élémentaires de construction destinées à éviter les accidents dûs à la fatigue des métaux.

ISOLEMENT D'ENROULEMENTS POUR MACHINES TRACTRICES: 3ème Partie

par W. Duckett page 221

Troisième d'une série de trois articles traitant respectivement des isolements catégories B, F et H. L'auteur s'occupe principalement d'une technique de presse spéciale qui permet de produire des bobines de dimensions déterminées.

ETUDE DES COMMANDES HYDRAULIQUES : 2ème partie

par J. A. Coates page 228

Cette deuxième et dernière partie de l'étude comporte une liste des principaux fournisseurs et fabricants d'appareils de commande hydrauliques.

CAOUTCHOUC BUTYLIQUE

par T. H. H. Skeet page 236

Discussion des principales caractéristiques du caoutchouc butylique synthétique et de plusieurs de ses applications dans l'industrie.

Kurzreferate

EINE EINFÜHRUNG ZUM PROBLEM DER METALLERMÜDUNG

von G. M. Astles Seite 212

Der Autor befasst sich mit der Natur der Metallermüdung, mit Methoden zur Bestimmung der Ermüdungseigenschaften von Werkstoffen, mit den die Ermüdung bestimmenden Faktoren, Theorien über den Grundmechanismus der Ermüdung und schliesslich mit einigen grundsätzlichen Konstruktionsmethoden, um Ermüdungszusammenbrüche hintanzuhalten.

ISOLIERUNG DER WICKLUNGEN VON TRAKTIONSMASCHINEN: TEIL 3

von W. Duckett Seite 221

Der dritte einer Serie von drei Artikeln, die sich mit Isolierungen der Klassen B, F und H befassen. Der Verfasser bespricht hauptsächlich ein besonderes Pressverfahren zur Herstellung von Spulen bestimmter Grössen.

HYDRAULISCHE ANTRIEBE : Teil 2

von J. A. Coates Seite 228

Dieser abschliessende Abschnitt der Übersicht bildet den Schluss der Zusammenstellung der Hauptlieferanten und -Erzeuger von hydraulischen Antrieben.

BUTYLGUMMI

von T. H. H. Skeet Seite 236

Eine Besprechung der Hauptkenndaten von Butylkunstgummi und einiger seiner industriellen Anwendungsmöglichkeiten.

Резюме

ВВЕДЕНИЕ К ПРОБЛЕМЕ УСТАЛОСТИ МЕТАЛЛА

Г. М. Астлс стр. 212

Автор статьи обсуждает свойства излома усталости, методы испытания металлов для определения свойств усталости, факторы, от которых зависит степень усталости, теории основной механики усталости и некоторые элементарные методы конструкции с тем, чтобы избежать излома усталости.

ИЗОЛЯЦИЯ ОБМОТОК ДЛЯ ДВИГАТЕЛЕЙ ТЯГИ: ЧАСТЬ 3-ая

В. Дакетт стр. 221

Третья из трех статей, рассматривающих изоляцию категорий B, F и H. Внимание уделяется главным образом особой технике прессовки для производства обмоток заранее установленных размеров.

ОБЗОР ГИДРАВЛИЧЕСКИХ ВОЗБУДИТЕЛЕЙ : ЧАСТЬ 2-ая

Ж. А. Коте стр. 228

Заключительная часть обзора содержит последнюю часть списка главных поставщиков и фабрикантов гидравлических возбудителей.

БУТИЛОВАЯ РЕЗИНА

Т. Х. Х. Скит стр. 236

Рассмотрение главных характерных свойств бутиловой синтетической резины и некоторые ее применения в машиностроении.

MATERIALS IN THE NEWS

Monthly Digest of Materials and Design News from Home and Abroad

Drawing Office Equipment and Materials Exhibition

THE FIRST NATIONAL Drawing Office Equipment and Materials Exhibition in the U.K. is to be held in the Royal Horticultural Society's New Hall, Westminster, from June 5-8, 1961.

The exhibition is being held to give facilities to manufacturers of drawing office equipment and materials to show their specialised equipment and the latest developments in this industry. Virtually every requirement for the drawing office in all branches of industry will be on display during the four days of the exhibition.

Both British and overseas equipment will be on show. Nearly half the available stand space has already been booked, and it is anticipated that this first exhibition will be so well supported that a larger hall will be necessary when it is held again in 1963. The organisers are UTP Exhibitions Ltd., 9 Gough Square, Fleet Street, London, E.C.4.

Soldering Glass

MOST DESIGNS employing glass sight windows rely upon sealing compounds or gaskets with frames to retain the glass. By metallizing the glass however, it is now possible to solder the glass directly to a suitable metal bezel. In this process, carried out by the Corning Glass Works, the joint is made air tight and rated for a differential pressure of 15 p.s.i. Alternatively the glass may be fused directly on to the metal, giving a bursting strength of about 2,500 p.s.i. In order to solder, a base coat of silver must be given to the glass, followed by an electroplated copper coating which will accept tin. (Enquiries should be sent to: 3911 Crystal Street, Corning, New York, U.S.A.)

The adhesion of metal films to glass is also discussed by Benjamin and Weaver in the Proceedings of Royal Society of Arts (No. 254, pages 177-183, 196), and results are given for gold, iron and aluminium coatings. In the case of iron and aluminium, ageing effects were observed which varied with the residual oxygen concentration. The differences between the ageing curves are explained in terms of the film structures as obtained by electro microscopy. The results indicate that iron and aluminium are both strongly bonded to the glass by an intermediate oxide layer, whereas gold does not form such a layer and is held by van der Waals' forces only.

New Fan Engine

THE BRISTOL SIDDELEY BS.75 is the first high by-pass ratio fan engine in the world to be designed as such from the start. Fan engines with these ratios have been produced in the U.S.A. by modifying existing turbojets, while in the U.K. new engines with low and medium by-pass ratios have been built and used very successfully; however the, BS.75 and the lift-thrust BS.53 are the first entirely new designs which exploit the by-pass principle to the limits set by current knowledge.

It is interesting to recall that Frank Whittle (later Sir Frank) patented the by-pass principle some twenty years ago, and the first engine of this type was built by Metro-Vick in the late 1940's.

The by-pass or ducted fan engine combines many of the advantages of the turboprop or turbojet. For quietness, economy and take-off performance, the turboprop is unrivalled. This is because the propeller acts on a large mass of air and projects it backwards at a relatively slow speed. But air-screw limitations restrict operating speed to about 550 m.p.h. (885 km.p.h.). The narrow, high velocity efflux of the turbojet is a more efficient means of propulsion at high speed, but is inefficient and uneconomical at low speed. Moreover, the noise of the jet cannot be greatly reduced without prohibitive loss of efficiency.

The ducted fan or by-pass engine is, in effect, a jet to which a fan or oversized compressor has been fitted. The fan acts not only as a compressor for the air entering the combustion chamber, but as an airscrew which forces a considerable mass of air through the fan duct, by-passing the combustion chamber, to the rear of the engine. The ducted air travels more slowly than the jet efflux and remains a lot cooler, thus giving greater propulsive efficiency at low speeds and creating less noise. (Enquiries should be addressed to: Bristol Siddeley Engines Ltd., P.O. Box 17, Coventry.)

Aircraft Nuclear Propulsion

THE U.S. ATOMIC ENERGY COMMISSION has completed the last test phase of a series of heat transfer reactor experiments, conducted by the General Electric Aircraft Nuclear Propulsion Department to verify aircraft nuclear propulsion reactor design factors and operating characteristics.

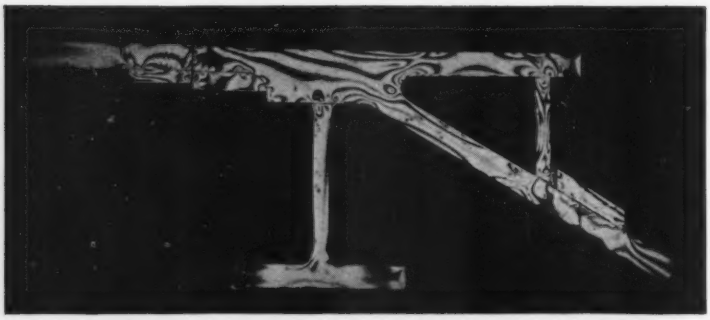
In January 1956 a turbojet engine, a modified J-47, was operated exclusively on heat supplied from a nuclear reactor, and up to January 1957 operated for more than 150 hr. completely on nuclear power. The unit consisted of a nuclear reactor, the radiation shield, assorted instrumentation and two turbojet engines (either of which could be operated by the reactor). No attempt was made to restrict the size and weight to approximate a flight version. It was deliberately made large for ease of access, and to accommodate the test equipment. These tests demonstrated the feasibility of the direct cycle aircraft nuclear propulsion system.

The second experiment was to test new material proposed for use in building future aircraft nuclear propulsion power plants.

A third unit in a series of heat transfer reactor experiments was built to test higher performance reactors. It was also the first design in a horizontal configuration, such as would be required for flight purposes. The reactor core of this unit uses concentric ring metallic fuel elements and a solid moderator material, and is capable of operating at approximately 1,090 deg. C., being cooled by air provided from two modified J-47 turbojets. During the period from September 1959 until December 1960 the power plant operated for 146 hr. at full power operation, with 65 hr. of continuous operation. Thus, for the first time, two jet engines were run simultaneously on nuclear energy.

In November 1960 the last phase of testing began. During this phase another objective in the programme was attained when two turbojet engines were started and brought up to normal operating range on nuclear power alone. In previous tests the turbojet engines had been started with chemical fuel and, once having obtained the normal operating range, had been transferred to nuclear power. The all-nuclear start is considered important because heretofore it has been considered necessary to follow the chemical-to-nuclear power transition in order to avoid large thermodynamic stresses in the reactor. In addition, valuable operating experience for use in more advanced nuclear propulsion systems has been obtained.

The General Electric Company is now developing the direct cycle aircraft nuclear propulsion system under contract to the U.S. Atomic Energy Commission and the U.S. Air Force, while the U.S. Atomic Energy Commission and N.A.S.A (National Aeronautics and Space Administration) have invited proposals for research and development of a nuclear rocket engine. The selection, although it will be based on a company's capability to carry out the entire nuclear engine development programme, will result initially in a contract for the first phase of the programme only. This phase will include assistance in the conduct of a test programme, the conduct of a preliminary design of the flight engine, the formulation of an engine development programme, and the performance of certain research and development tasks on non-nuclear components.



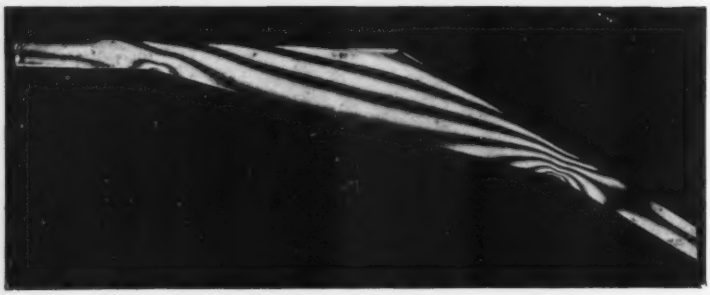
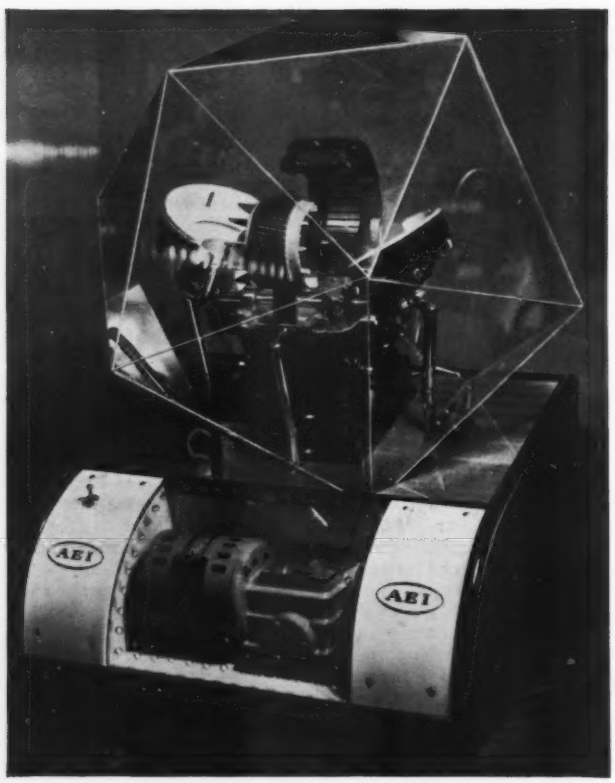


PHOTO-ELASTIC TECHNIQUE

The two photographs on the left show the improvement in structural behaviour of a cone-ring-cylinder intersection on a pressure vessel, gained by a simplification of design. They demonstrate an interesting feature of the work on three-dimensional problems being carried out by the Research Division of the College of Engineering, New York University.

PICTURE NEWS

IN THE WORLD OF MATERIALS & DESIGN

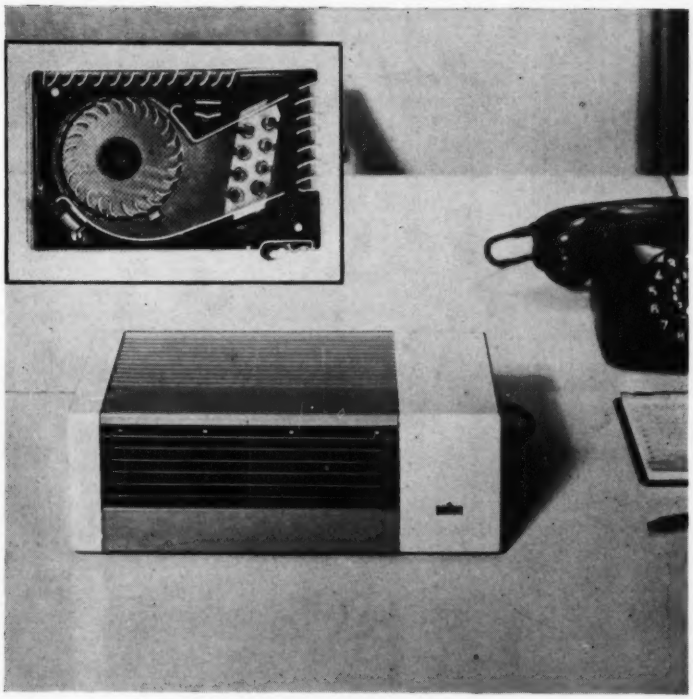


ALUMINIUM CABLE

Since Solidal plastics-insulated aluminium cable was introduced by Alcan Industries about a year ago, much experience has been gained in its use. Above, a soldered service T connection on Solidal cable is being made in the course of installation work on a housing estate. (By courtesy of Midlands Electricity Board.)

DESIGN DISPLAYED

This eye-catching exhibit is a working model of an A.E.I. fractional horsepower electric motor—it is to be shown at the forthcoming A.S.E.E. Exhibition.

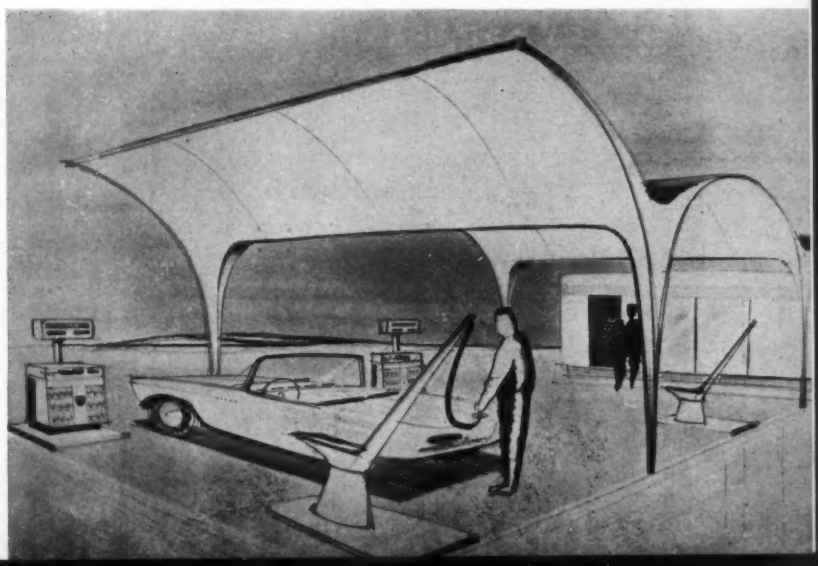


PORTABLE THERMO BLOWER
Seen on the left is a new product of the Max Braun development division, designed in conjunction with the Laing Physicotechnical Development Bureau, Stuttgart. Axial ventilation (with an impeller) has given way to tangential ventilation employing a fan-cylinder, operating on the Eck-Laing principle.

SMATKO FUEL CELL
Shown above is a new fuel cell developed by Dr. J. S. Smatko, of the Hoffman Science Center, U.S.A. It uses sodium, bromine and mercury to produce an open circuit voltage of 2.8 V. per cell. Peak current densities up to 10,000 A./sq. ft. are claimed for periods of one-tenth of a millisecond.

RELAXED ROCKET
Only an astronaut would guess it, but the pipelike piece of machinery seen above, held firmly by a vice, is a rocket motor which simulates the temperatures and pressures of a satellite-carrying rocket. A Goodyear technician is shown removing an inner section containing samples of experimental liners.

AUTOMATIC FILL-UP
A revolutionary new system for dispensing motor fuels, designed by the British Petroleum Co., is known as Autovista. Several grades of fuel or mixtures can be preselected on dials which can be set for either money value or volume. Autovista can be easily adapted for a coin self-service system.



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Titanium Improvements

IN THE RELATIVELY SHORT TIME that titanium has been available as a material of construction, many different alloy compositions have been developed. Each offers a combination of properties best suited for a particular application. Thus, alloys are now available for high strength uses, where hot-working or welding considerations are important, and for applications requiring high formability.

A new alloy shortly to be made commercially available by a British company represents a considerable achievement, since this material has sufficient ductility to be easily worked and yet is capable of being heat-treated to a considerably higher strength. Containing 15 per cent. Mo, the new alloy has already been evaluated under service conditions by leading manufacturers.

Another new alloy, produced by Union Carbide Metals Co., is a simple and relatively inexpensive 0.1 per cent addition of palladium to commercially pure titanium. The additive permits the use of titanium in reducing environments; for example, in strong reducing acids such as sulphuric and hydrochloric.

Similar work with noble metals has been carried out by the Russians, who have alloyed platinum and palladium with stainless steel. It would appear, however, that alloying with a noble metal is most effective with titanium. One of the disadvantages of titanium is its tendency to gall, but a binary titanium alloy by I.C.I., containing a small percentage of beryllium, can be heat-treated to give it a hard surface layer with enhanced resistance to wear and galling, and a core which retains reasonable strength and ductility. No loss of surface hardness is likely to occur at service temperatures below 300 deg. C. The alloys are heated to a temperature between 820 deg. C. and the upper temperature limit of the field, and are then quenched in brine, water or oil. If required, ductility can be further increased with some loss of surface hardness by reheating at 400-820 deg. C.

Another titanium alloy, designated EP-20-2, has been produced in the U.S.A. by Manganese Chemicals Corporation. It contains 20 per cent aluminium and 2 per cent vanadium, and has a tensile strength of 190,000 p.s.i. with 6 per cent elongation at room temperature. Strength at elevated temperatures is high, u.t.s. values at 650 and 980 deg. C being 130,000 and 50.000 p.s.i. respectively.

Titanium is selected for most applications because of its excellent strength-to-weight ratio and/or its outstanding resistance to many corrosive media. Titanium has other characteristics, however, which have had limited application in the past, but which may be the key to many important new applications. One of these properties is its electrical resistivity.

Titanium exhibits the normal electrical resistivity characteristics of all metals, in that resistance increases with the addition of alloying elements and with increases in temperature. Titanium containing 7 per cent Al, 4 per cent Mo, and titanium with 6 per cent Al, 4 per cent V, as produced by the Crucible Steel Co. of America, show a relatively flat response to increases in temperature and significantly higher resistivity than Nichrome*. These features should prove advantageous in such applications as heating elements, or as wiring for electrical equipment which operates at peak efficiency over a wide range of temperature.

In many applications, heating elements work at a temperature sufficiently low to ensure that the rate of oxygen diffusion is so slow that embrittlement of the wire offers no serious problems. When exposed to the atmosphere at temperatures in excess of 700 deg. C., titanium will form an oxide layer; nickel plating, an effective barrier to oxidation, might be utilised to solve this problem.

Skin for Space Craft

AFTER NEARLY TWO YEARS OF RESEARCH into the problem of finding a coating to protect certain metals against deterioration from heat and air friction, a skin with the desired qualities has recently been devised by the Boeing Airplane Company, Seattle, Washington, U.S.A. Less than 0.001 in. thick, it is expected to protect space craft against the heat generated by friction such as would be encountered on re-entry into the earth's atmosphere at speeds near 18,000 m.p.h.

The new coating is especially intended to protect alloys of columbium and molybdenum. Available in sheet form, these alloys can be fabricated into complex structures and retain their strength at high temperatures. On the other hand, columbium alloys when heated in flowing air form yellow to white oxides, which melt at approximately 1,450 deg. C. At this temperature, the exposed base metal becomes incandescent and rapidly deteriorates. Under similar conditions, molybdenum alloys give off white smoke and form black scales, and the rate of metal loss is even greater than is the case with columbium alloys.

Before exploring new types of coating, Boeing tried out existing materials, but for one reason or another these failed to measure up to requirements, viz. the prevention of formation of oxides under stress, vacuum and vibration. In addition, the coated alloy had to be inspectable; retain its base-metal properties; be reliable; transfer heat rapidly at service temperature; have easily reproduced physical and chemical characteristics; be repairable if damaged; and be chemically compatible with adjoining materials. The coating also had to be applicable to complex joined parts.

Known as the Disil process, the new metal finishing treatment involves the application of silicon and other materials to the surface of the molybdenum. The part to be coated is packed in a retort containing blended powdered materials. The retort is sealed and heated in a furnace to temperatures between 930 and 1,090 deg. C. After a soak at these temperatures, the retort is extracted from the furnace and allowed to cool, following which the parts are unpacked, the residual pack agent being removed from the coated part by light brushing and water rinse.

The black, hard coating on molybdenum has good erosion resistance, is not porous and has good shock resistance and good self-healing properties above 1,370 deg. C. It remains stable at temperatures higher than 1,760 deg. C., and weighs only 0.1 lb. per sq. ft. In tests, negligible weight changes have occurred when the coated metal has been heated to 1,480 deg. C. in air, and exposures in oxidising gas streams for more than 1 hr. at 1,650 deg. C. have not detrimentally affected the coating. Specimens heated to 1,480 deg. C. and loaded to 8,000 p.s.i. have demonstrated the coating's ability to protect the metal while under stress and heat in an oxidising atmosphere. The coating has also been tested on a columbium alloy with good results, the alloy being protected for 1 hr. 45 min. at 1,650 deg. C., and for 15 min. at approximately 1,870 deg. C.

Further tests are being carried out at the Boeing plant to determine the usefulness of the coating. Other possible applications include combustion chambers and tail pipes of advanced air-breathing power plants, turbo-jet nozzle guide vanes, and heat shields for ballistic re-entry bodies.

A coated metal strip being tested for heat and tension.

* *British Driver Harris Co. Ltd.*

E.M.D. 0127 for further information

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Fracture of Metals

A VACATION COURSE is being organised from April 11-14 to give an overall picture of recent work in the field of fracture of metals. All the lecturers have been selected for their first-hand knowledge of the subject. The topics to be covered will include: the practical problems of fracture in service; mechanical testing methods for the assessment of fracture behaviour; theoretical aspects of fracture; the ductile to brittle transition in ferrous and non-ferrous metals; the effect of irradiation on fracture behaviour; temper brittleness in steels; hydrogen embrittlement of metals; fracture under creep conditions; and fracture under fatigue conditions.

There will be ample opportunity for questions and discussion. Enrolment forms may be obtained from the Secretary (Metallurgy Courses), Battersea College of Technology, London, S.W.11.

Fire Protection Development

TURNERS ASBESTOS CEMENT CO. LTD. report successful tests on the application of asbestos ships board for the protection of aluminium decks against fire. They claim to be the first company in the world to achieve this. This development is important because it will allow shipbuilders to use aluminium deck members in their vessels instead of mild steel, thus giving a much lighter superstructure.

Sections of aluminium deck protected by the new method were heated from below for 1 hr. After 5 min. the temperature had risen to 600 deg. C., and it continued to increase until it was well over 900 deg. C. However, at the end of the hour, the temperature on the upper surface of the deck had only risen to a little more than 100 deg. C. Successful completion of this test means that the material has achieved the standards laid down in the International Convention for the Safety of Life at Sea for fire-resisting divisions on passenger ships. (Enquiries should be addressed to: Trafford Park, Manchester 17.)

Thermoelectric Cooling

COMPACT, SOLID COOLING UNITS are now being made from small pieces of special semi-conductor materials. This development is the outcome of an extensive research programme into new semi-conductor materials carried out at the Hirst Research Centre of The General Electric Co. Ltd.

Pieces of two different bismuth antimony telluride alloys are electrically connected to form a thermocouple. Several of these, placed side by side and joined together, make a flat-sided rectangular cooling block. A temperature difference is developed between opposite faces of the unit when a d.c. current is passed through the thermocouples. The maximum temperature difference attainable with simple arrangements is 78 deg. C. but 45 deg. C. is a more normal value under working conditions. Units having different numbers of thermocouples provide cooling power ranging from a fraction of a watt to 10 watts.

In use a thermoelectric cooler is clamped between an object to be cooled and a finned block or water cooler which dissipates the heat from the hot surface. The units can be used to cool components of electronic equipment, parts of instruments and metal containers.

THE MAY ISSUE

of *Engineering Materials and Design* will include the following main features:

Low-temperature Rubbers

Discussion of low-temperature stiffening of rubbers, and how it may be obviated.

Design Formulae for Thick Cylinders

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Survey of the various types available.

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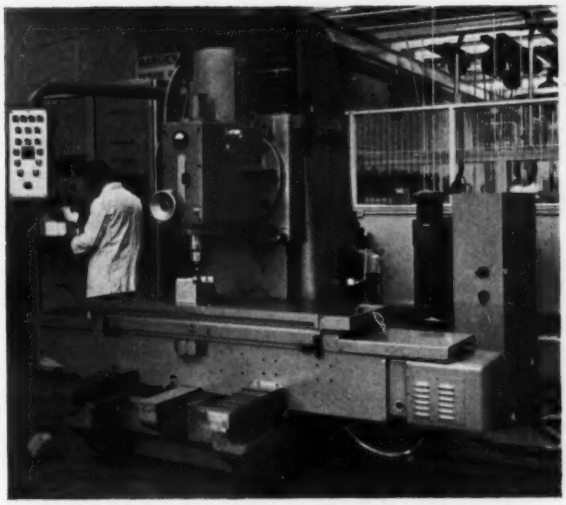
Dealing with the principles of operation, techniques of construction, and applications.



The FS 80 N vertical milling machine, equipped with the Emicon control system.

Machine Tool Thinks Ahead

THE E.M.I. - CONTROLLED DROOP AND REIN FS 80 N vertical milling machine foresees any programme irregularity or error in the tape which controls it. Previously, tape-controlled machines were equipped with a safety system which stopped the machine immediately an error had been made. The big advantage claimed for the new Emicon system is that the machine is stopped before the fault has affected the workpiece. Immediately the irregularity has been investigated and if necessary corrected, cutting can continue. If the workpiece has a complicated profile and the irregularity occurs near the end of the programme, a large saving is made by eliminating the scrapping of a valuable workpiece.

Droop and Rein (a leading German firm of machine tool manufacturers) have been making drilling and milling machines since 1890, but the FS 80 N vertical mill is the company's first tape-controlled machine. It is a general-purpose unit, particularly suitable for large die sinking because it is heavy and robust, and has a wide range of controlled movements.

The Emicon system fitted to this machine provides several other facilities. It gives continuous contour control in any two axes, and very fine step control with controlled feed speed in the third dimension. This speed can be independently set for "in" and "out" movements. A fully three-dimensional control system can be fitted to the machine if required. (Enquiries should be sent to: E.M.I. Electronics Ltd., Hayes, Middlesex.)

Emulsions for Hydraulic Fluids

THE FIRE HAZARD of hydraulic fluids has long been a serious problem, and the search for the ideal fire-resistant medium has not yet ended. Synthetic oils such as phosphate esters and chlorinated materials are inherently resistant to ignition, but these materials cost more than five times as much as mineral oils. Water/glycol lubricants consist of solutions of ethylene glycol in water, together with thickening agents and additives to provide rust protection and improve boundary friction properties. They are, however, still considerably more expensive than mineral oils, and they tend to attack paints and certain types of rubber which may be used in hydraulic systems.

Considerable development work is being carried out by the Shell Group on water-in-oil emulsions, which are relatively low in cost and at the same time have other advantages such as good rust protection, and the fact that they do not affect oil-resistant rubbers or paints. Although laboratory tests for fire resistance do not appear to simulate precisely the type of hazards encountered in service, it is evident that water-in-oil emulsions show a tremendous improvement in resistance to ignition compared to mineral oils. The Shell Oil Co. have marketed a water-in-oil material in the U.S.A. for several years, under the trade name Shell Irus Fluid 902. It is hoped that an improved material of this type will be available generally in this country in the near future.

Brazing Beryllium

THE METAL BERYLLIUM has many properties which are attractive to designers of high performance aircraft and nuclear reactors; it has a high Young's modulus, low specific gravity and low neutron-absorption cross-section. The actual use of this metal, however, has been limited by many factors, including its toxicity and room-temperature brittleness.

One of the critical areas to be developed if beryllium is to be used as a structural material is that concerned with the joining of beryllium to itself and other metals, especially for high-temperature applications. Accordingly, in co-operation with Wright Air Development Centre, a programme for developing improved techniques for joining beryllium has been carried out at Avco Corporation during the past year. The results of this work are contained in two reports—W.A.D.C. 59-695, Pts. 1 and 2 (O.T.S. 161830 and 161831).

Elementary Plasticity

IT IS PROPOSED TO GIVE a short course on the elements of the theory of plasticity, with applications to metal working processes, at Imperial College from April 10-14, 1961. This course is primarily intended for lecturers at colleges of technology who, under the new regulations of the Institution of Mechanical Engineers, are required to teach the theory of plasticity to A.M.I.Mech.E. candidates.

A detailed knowledge of three-dimensional stress analysis or tensor notation will not be necessary, and the emphasis will be on practical applications. Mathematical ability up to Higher National Certificate standard will be required. There will be tutorial periods during which those attending the course will have an opportunity to work out typical examples under the guidance of the lecturers.

Application for admission should be made to the Registrar, Imperial College of Science and Technology, South Kensington, London, S.W.7.

Design Appreciation Course for Senior Engineers

FOLLOWING ITS TWO SUCCESSFUL design appreciation courses for junior engineers, the Council of Industrial Design is organising a course for senior engineers. It will be held from April 25-28 inclusive, and should not be confused with the third junior course, which finishes early in April.

The senior course will have three main aims: to impart an appreciation of design in its widest context; to show how industrial design can be put into practice; and to emphasise the growing application of industrial design in engineering today. Particular attention will be paid to organisational questions as well as to general design appreciation, so the course should be of special interest to senior engineering staff with executive control or responsibility for engineering design teams.

Lectures in the first part of the course will deal with the development of industrial design, and with analyses of the factors which constitute good design, with special reference to both the part played by form, colour and composition, and also to human engineering or ergonomic aspects.

In the second part of the course, talks on design organisation directed towards using industrial design to the best advantage will be held with a leading manufacturer, a leading industrial designer and representatives of the CoID. The course will be held in London, and will be residential so as to make the fullest use of available time and encourage group discussion. (Enquiries should be sent to: The Design Centre, 28 Haymarket, London, S.W.1.)

Ultraviolet Radiation Detector

THE EDISON ULTRAVIOLET RADIATION DETECTOR is a stable, high-power electronic tube responding to ultraviolet radiation in ordinary flames. In addition to its use as a fire detector the instrument also has applications as a gas detector, where the gas reduces or obliterates a permanent ultraviolet source by its presence. It is insensitive to sunlight, cosmic radiation, infra-red and ordinary incandescent and fluorescent light sources, and is operative over the temperature range –65 to +200 deg. C. Its output is so large that it can operate electro-mechanical relays directly without amplifiers, and its associated circuitry is simple.

The tube has two symmetrical electrodes within the gas-filled glass envelope. It operates on a.c. circuit with each electrode alternately cathode and anode, or with rectified a.c. where the voltage of the electrodes approaches zero each half cycle but the polarity does not reverse. Ultraviolet light from external sources such as flames, containing wavelengths in the range 1,900 to 2,900 angstroms, releases electrons from the negative electrode. An electron emitted at an instant when the voltage between the electrodes is high starts ionization of the gas, which instantly builds up to an avalanche of current that continues to flow as long as the voltage is high enough during that particular half cycle. Near the end of the half cycle the discharge goes out for lack of driving voltage, to start again only on the emission of another electron during a subsequent half cycle of high voltage. When the ultraviolet radiation intensity is high enough to activate an appreciable number of the half cycles, the average transmitted current becomes large enough to operate a relay or other device.

The circuit is normally arranged so that it does not respond to a single half cycle pulse of current that might be initiated by cosmic rays, sunlight or other extraneous sources, but rather to the greater average current set up by a series of pulses initiated by the relatively stronger ultraviolet light source. The tube is operated by an a.c. supply potential of 700 V., with a load impedance of a few thousand ohms. Average currents between 1 and 25 mA. may flow, depending on the ultraviolet course intensity.

The choice of frequency for the energising voltage is arbitrary. Normally 60 c/s voltage is used, but for certain purposes frequencies up to 100 kc/s may be employed. For example, when the tube is used for quantitative measurement of radiation intensity, the supply frequency must be high enough so that a substantial number of non-conducting half cycles exist, at the highest radiation intensities involved.

The properties of the Edison ultraviolet radiation detector make it suitable for a variety of applications. It may be used in fire detection to give nearly instantaneous alarm, and it rapidly detects the absence of flame in boiler fire boxes, in furnaces and in other combustion chambers. The instrument has been developed over a period of seven years by the Instrument Division of Thomas A. Edison Industries of West Orange, New Jersey.

In this demonstration unit, the tube illuminates a red warning light upon detection of the candle flame. Alternatively, the tube can be connected to an audio alarm, or arranged to activate controls.

THE HUMAN ELEMENT IN INDUSTRY

THE ART OF ENCOURAGEMENT

IN suggesting a closer unity between the Amalgamated Engineering Union and the Association of Engineering and Shipbuilding Draughtsmen, the A.E.U. journal notes that because draughtsmen are employed in the early stages of production, and are usually separated physically from the people and processes on the workshop floor, there is sometimes a lack of understanding, and perhaps even a lack of appreciation by manual workers and technical staff, of each other's work and problems. This lack of understanding is also evident in many instances between individual members of the same group or office.

In a recent company report, JOHN OLDHAM, O.B.E., comments "At all times the personal touch has an essential place in the philosphy of management. Although it may on occasions be demanding, both in material cost and in time and energy, there is no substitute for the promotion of mutual understanding, goodwill and co-operation . . ."

With these sentiments there will be no disagreement, but their practical interpretation sometimes leaves much to be desired. Since human nature is so diverse, no rigid rules can be established for encouraging staff; each case and person must be treated according to nature and circumstances.

Broadly, one may encourage by leadership, by authority, by ridicule promoting fear, and by persuasion and example. Leadership involves the employment of all the other facets at the right time and in the right manner, and the number of such leaders is small; they are born, not trained. Any such employer usually has a willing, loyal and hard working staff, which is fortunate in having an employer who understands both the strength and weakness of human nature. Thus the partnership is mutual.

The use of authority is far too often abused, breeding a certain fear and contempt. Ridicule, indiscriminately applied, can be dangerous, even to the detriment of physical and mental health, and in the extreme will bring out the worst in human nature. Imagine the effect of a sensitive employee being referred to by name in a company's internally circulated news sheet in the following terms: "The dunces of the week are Mr. X and Mr. Y, with sixteen orders. This is disgraceful, and I require far better returns than this from both representatives in the future." One can only imagine the sort of returns the author of this little homily would receive if these sort of tactics were tried in some branches of industry! Possibly he feels that in these modern times of high pressure and competitive selling one cannot afford to be sensitive, or to be an individual, but this attitude is in most cases a facade, and represents a short term policy which can do little but harm.

Encouragement by example and by rational persuasion will achieve the best results when practiced with sincerity. Compliments should be given when deserved and errors should be explained. Those with big heads require cutting down to size, but at the same time success should be recognized.

All this requires time and patience, which no doubt many busy managers will say they can ill afford. Our modern life unfortunately leaves little time for reflection on the individual human problems in industry, this is now left to the expert to study and report upon. A little more time for reflection by the immediate boss is the answer to a host of little difficulties which may by themselves turn into big problems.

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AT LAST—A MATERIALS COURSE !

BY complaining so often about the difficulties of finding men who have been trained in engineering materials, we have only been echoing the comments of those far-sighted engineers who have realised that our education system is out of date in this respect. We therefore give a sincere welcome to the news that the College of Engineering Technology, at Rugby, is to make a serious effort to remedy this defect by introducing a course which will break new ground by teaching the science of materials as a subject in its own right.

The proposed course will lead to the award of a Diploma in Technology (Applied Physics), and it is hoped that the Institute of Physics will approve this Diploma as a qualification giving exemption from the Graduateship examination. The course is scheduled to start in September; it will be arranged on the sandwich system and will extend over five years, with six months' full-time study at the College and six months' industrial training in each year. Some engineers may object to the course being run under the heading of physics rather than engineering, but, after all, engineering is really only a branch of applied physics! In any case, a little more physics and a little less of the blacksmiths' witchcraft might not be a bad thing in some branches of engineering!

The aim of the course is turn out a "horizontal" specialist who is not a chemist, a metallurgist, a physicist or an engineer, but a man who can link together all engineering materials by a common factor—the structure of matter. By studying from first principles the fundamental science associated with atomic, electronic, crystal and molecular configurations, the student will be able to assess and compare such diverse materials as metals and ceramics, plastics and semi-conductors.

We recently met Dr. G. S. Atkinson, Principal of the College, and his enthusiastic staff headed by Dr. J. S. Wignall, who explained that one of the most interesting features of the new course is the way in which practical laboratory work will be tackled. A real attempt will be made to avoid stereotyped experiments in which the student follows, stage by stage, a series of set operations. Such experiments have in the past served as the practical side of science courses. Instead, the student will be encouraged—perhaps even forced—to think for himself by having practical experiments outlined only approximately; he will then have to work out the full details himself by studying in the library, or by consulting the staff. For instance, he may be asked to prepare a ferrite from oxide powders by pressing and sintering, but he will be allowed considerable freedom to experiment with proportions and heat-treatments to verify the expected combination of properties.

In most teaching organisations, it has been discovered that suitable staff are not attracted unless a flourishing research school is developed side by side with the teaching scheme. The Rugby College believe that it is impossible for a teacher to keep up to date and retain the respect of students and of colleagues in industry unless he is actively engaged in research and development. The College activities in the field of semi-conductors and magnetic materials suggest that the staff will not let the rapid developments in materials leave them behind.

This is a bold experiment, and one which deserves to succeed. It can only do so if the necessary support comes from industry. Rugby is a good centre for establishing a materials course, because it is readily accessible from many large industries and research organisations who stand to benefit from it. It is to be hoped that those who have in the past complained about the lack of interest in materials by the educational authorities connected with engineering will not let this opportunity pass.

The Editor

AN INTRODUCTION TO THE PROBLEMS OF METAL FATIGUE

The author deals with the nature of fatigue failure, methods of testing materials to establish fatigue properties, factors affecting fatigue strength, and some elementary methods of design to overcome failure by fatigue

by G. M. ASTLES, A.M.I.Mech.E.

THE problems of fatigue in metals first attracted the attention of engineers about the middle of the last century, when there was a great increase in engineering work in general, and particularly in connection with the railways. At this stage little work had been done to evaluate the effects of repeated cyclic loading.

Tests were devised to examine unexpected failures which had occurred in service, and it was shown that there was no deterioration of strength with time, but that where loads were applied cyclically, failure could occur after a finite number of stress cycles, even though the stress was well below the ultimate tensile strength of the material. Among the early workers in this field, Fairbairn and the German Wöhler made notable contributions.

The Present Problem

Today, failure by fatigue implies fracture of a component due to the spreading of a fine crack initiated by cyclic applications of load, and characterised by a smooth, silky, fracture-surface. Typical fracture surfaces are shown in Figs. 1 and 2.

It was established by the early research workers that for many metals and alloys there is a definite level of stress, below which failure by fatigue will not occur. This gave rise to the concept of a limiting fatigue stress for a given material, and much work has been carried out since to evaluate limiting stresses for different metals and alloys under various conditions.

To determine the limiting fatigue stress, a series of tests is carried out at different stress levels, and a curve plotted of stress S against number of cycles to failure N. A typical S-N curve for an alloy steel is shown in Fig. 3, from which it will be noted that the curve becomes virtually asymptotic to a particular stress value, this being the limiting fatigue stress referred to above. The S-N curves for steels and many other alloys have a characteristic knee or sudden change of slope of the curve, which usually occurs at between 2 and 4 million stress cycles. It must be emphasised that the value of limiting fatigue stress so obtained applies only to the particular conditions of test, the behaviour of metals under fatigue conditions being greatly influenced by metallurgical, geometrical and environmental factors. It should also be noted that, while for steel and some other alloys the S-N curve approaches a limiting value, the curves for copper and many of the light alloys do not, and must be interpreted with great care, avoiding extrapolation (see Fig. 4).

Table 1. Effect of various surface finishes on fatigue strength (Moore and Kommers)

Surface finish	Fatigue limit			
	0·49% C steel		0·02% C steel	
	kg./mm.²	%	kg./mm.²	%
Polished with 0 and 00 emery cloth	±35·2	100	±18·5	100
Polished successively with 0 and 00 emery cloth, 1, 0 and 00 emery papers and rouge	±36	103	—	—
Circumferentially ground	±32·3	92	—	—
Finely turned	±30·7	87	±17·1	92
Roughly turned	±29·6	84	±16·5	88

Different kinds of repeated application of stress can lead to fatigue failure. Thus, a fixed structure may be loaded and unloaded, as in the case of bridge members, or the shaft of a machine may be subject to an alternating stress, varying from a peak tensile value through zero to an equivalent peak compressive value. The cyclic stress may be direct, bending or torsional, or any combination of these three.

With the ever-increasing demands of the designer with regard to strength/weight ratios, it has become increasingly important to establish safe working stresses as accurately as possible, to reduce the factor of ignorance applied in design calculations, and in general to make full use of the material embodied in a component.

Methods of Test

In order to establish safe working stresses, it would be preferable to test actual components under their designed working conditions; this is rarely practicable. However, many types of testing machine have been evolved to apply different forms of stress, either singly or in combination, to suitable test specimens.

The direct stress machines are arranged to provide either tensile or compressive stresses, or any range of stress between upper and lower limits. An example is the Haigh alternating direct stress machine (Fig. 5). This machine is operated electro-magnetically, the specimen S being fixed

The original full-length article was presented as a paper at a meeting of the North Western Branch, Graduates' Section, of The Institution of Mechanical Engineers.

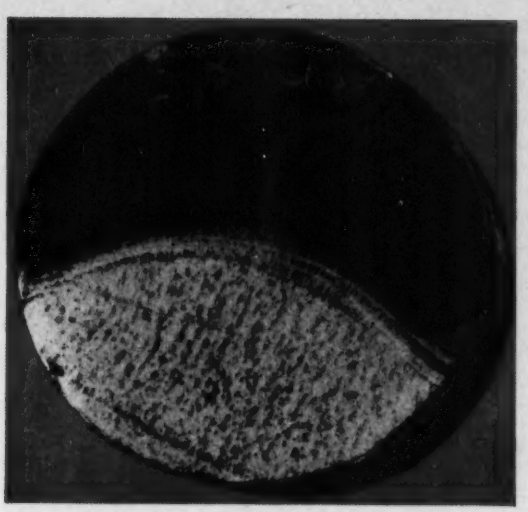

Fig. 1. Fatigue fracture surface. The dark area shows the extent of the fatigue crack, and the light area the final ductile failure of the shaft.

Fig. 2. Fatigue fracture surface initiated by fretting corrosion damage. (A—origin of main crack; B—origin of subsidiary crack.)

at one end, and at the other attached to a rod carrying an armature A, which is situated between the poles of a powerful two-phase electromagnet M.

For shafts and other rotating parts incurring bending stresses, calculations are mostly based on the results of tests made with the rotating-beam type of machine (Fig. 6). The specimen S is clamped at one end in a chuck which can rotate, and at the other end carries a bearing B, supporting a load W. It will be seen that the specimen is thus arranged as a cantilever, and that the maximum bending stress will occur in the plane XX in the case of a parallel specimen. As the specimen is rotated, any particular surface element will suffer a sinusoidally varying stress.

There are many different varieties of testing machine, but the two examples given above will serve to show the general principles of fatigue testing for the provision of design information.

Factors Affecting Fatigue Strength

Size Effect—In the case of plain specimens or components without stress-raising grooves or notches, it has been found that the size of the specimen has little effect on the limiting fatigue stress under conditions of alternating direct stress. In the case of bending stresses the limiting stress is initially higher, but is lowered as the size of specimen increases. The reduction is not severe, however, as the limiting stress tends to approach the value for the material if subjected to alternating direct stress.

With specimens where stress concentration effects exist, the size effect may be much greater. It has been found that where localised high stresses exist, no crack will develop unless the region of high stress is above a certain minimum size, which varies from material to material. Thus, although two geometrically similar specimens of the same material may have the same theoretical stress concentration effect, the larger one will be more susceptible to fatigue failure. In this connection it is important to differentiate between the theoretical stress concentration factor, based solely on the geometry of a component, and the fatigue strength reduction factor, which is established by fatigue testing, and will show variations due to size effect where no theoretical difference exists.

Surface Finish—The influence of surface finish on fatigue strength has long been recognised, and can perhaps best be illustrated by the comparative results of tests on two different steels with five different surface finishes, as published by Moore and Kommers[1] (Table 1). In general, the rougher the surface finish, the lower the fatigue strength, the reduction in strength being more marked with hard than with soft steels.

Internal or Residual Stresses—Any internal or residual stresses in a material may, according to their nature, reinforce or subtract from the effects of the externally-applied stress, thus reducing or improving its fatigue resistance.

It is interesting to note that, in the case of surface polishing of a test specimen, the beneficial effects are twofold; first because the polishing removes scratches and surface damage, and second in that the tensile peak stresses of a fatigue cycle are reduced by the residual compressive stresses introduced into the surface by the polishing process.

Effect of Mean Stress—In many practical cases, the

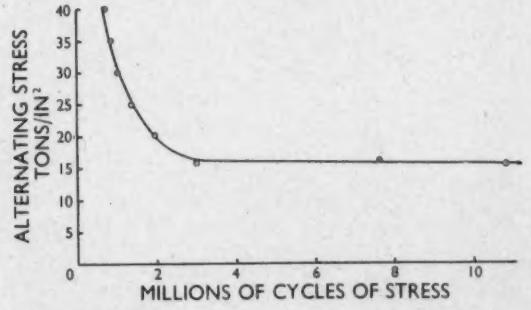

Fig. 3. Typical S-N curve for an alloy steel.

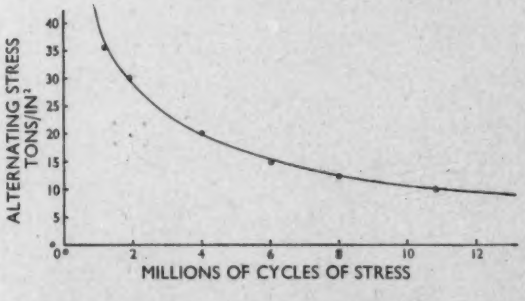

Fig. 4. Typical S-N curve for copper alloy.

stresses applied take the form of an alternating cycle superimposed on a constant static stress. In such cases the range of stress, which is the algebraic difference between the maximum and minimum stress values of the cycle, is the criterion of fatigue failure. Some metals maintain a fatigue range which is almost constant so long as the static stress does not exceed the elastic limit, while others show a reduction in fatigue range as soon as any static stress is applied.

GEOMETRICAL EFFECTS—It has been shown that the geometry of a component has a profound effect on its fatigue properties. This is principally due to the stress-concentration effects produced by changes of section, as in notches, holes, keyways and splines. These effects will be dealt with in greater detail later.

SPEED EFFECTS—Within the limits of normal engineering practice, it can be said that the rate of application of stress cycles has no effect on the fatigue strength of a material. At very high rates of stress reversal, however (above 1,000 c/s, say), some improvement in fatigue strength is apparent.

TEMPERATURE EFFECTS—With temperatures above 200-300 deg. C., a progressive deterioration of fatigue strength usually occurs, which is more pronounced at temperatures which give rise to subsidiary creep effects. Under sub-zero temperature conditions there is some improvement in fatigue strength for most materials.

REST PERIODS—If a specimen is subjected to a number of stress cycles, and then rested for a period before continuing the test, it might be expected that some improvement in life would result. In general this is not the case; the fatigue damage is cumulative, and the total number of stress cycles to failure is unaffected by intermittent rest periods. Some workers have claimed improvements by use of special test cycles including rest periods; it is doubtful if any beneficial effects result from the normal resting of a component in normal service.

ENVIRONMENTAL EFFECTS—Fatigue failure is accelerated by any form of corrosion, and in fact the processes may be said to be mutually catalytic, the two together producing far worse effects than either of them singly. It should be noted that in this connection relatively harmless agents may be termed corrosive. For example, ordinary tap water may affect the fatigue properties of many steels considerably.

Where corrosion is present there is no limiting fatigue stress, the S-N curve being more or less steep according to the severity of the corrosive action.

EFFECT OF SURFACE TREATMENTS—It is at first sight rather surprising to find that most electroplating processes result in a reduction of fatigue strength, especially as the surface finish is of a smooth, polished nature. In most cases, however, the electroplating process introduces residual tensile stresses into the protective surface layer of the component. These reinforce the applied stress, thus leading to failure at a lower nominal stress level. Under corrosive conditions, however, electroplating may be an advantage.

Other surface treatments, such as shot-peening, rolling and polishing, improve fatigue resistance by introducing compressive stresses into the surface. Particularly noteworthy is the effect of nitriding, which, in addition to giving a general improvement in fatigue strength, lessens the effects of notches and surface damage, provided the nitrided layer is continuous and unbroken.

UNDERSTRESSING—Understressing is a method of improving the fatigue strength of a material by subjecting it to a large number of reversals of a stress just below its nominal fatigue limit. Subsequent application of stresses at, or slightly above, its nominal fatigue limit can then be borne without failure occurring. The extent of this improvement varies with different materials, greater improvement

being possible with the harder steels than with the softer, while some materials show no improvement whatever. No commercial use has been made of this phenomenon, as the results cannot be predicted with certainty.

NATURE OF THE STRESS CYCLE—It may be that a machine is subject to fatigue action only under certain conditions, as when starting and stopping, or possibly when overloaded. In this way damage may result in a cumulative fashion, until the stage is reached where the stresses occurring under normal running conditions are sufficient to maintain crack propagation. Fracture will thus occur where it would not if overloads of a transient nature could be avoided.

While they do not cover every influential factor, these details indicate the variety of interdependent processes which may contribute to a particular fatigue problem.

Basic Theories

When one comes to consider the nature of the fatigue process, two approaches are in evidence by different workers. On the one hand, the phenomenological evidence of fatigue failures has been considered, and this has largely been the source of information of use to designers and engineers. On the other hand, fundamental work has been carried out on the structure and properties of metals at the molecular level, using electron microscopes and x-ray diffraction techniques to study the effects of lattice structure, discontinuities and slip bands.

In speaking of a limiting fatigue stress, or fatigue limit, it must be appreciated that the information obtained is of a statistical nature, and subject to a certain level of probability based on the number of tests carried out.

It is impossible to deal adequately with the most recent work along these lines in a general article such as this, especially as no complete understanding of the process has been found as yet.

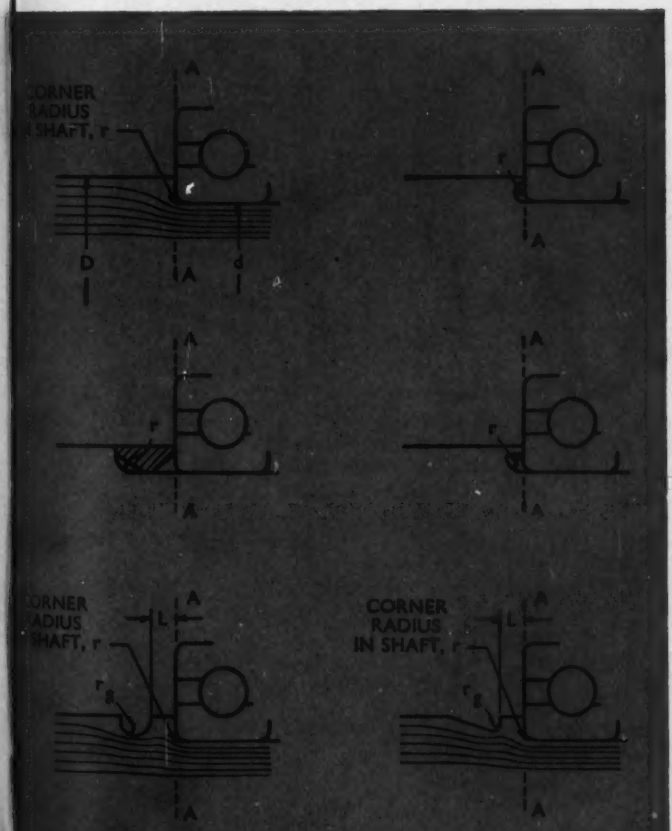

Fig. 8. Relief grooving. (Stress Concentration Design Factors, by R. E. Peterson. (John Wiley & Sons Inc., New York).)

Designing to Avoid Fatigue

Although no completely acceptable theory of the mechanism of fatigue is available, most fatigue failures can be attributed to poor design, and can be avoided by taking suitable precautions.

It has been established that while there is a limiting fatigue stress for most iron and steel alloys, this limiting stress is subject to variation, and can be reduced by such things as surface finish defects, tensile residual stresses or stress concentration effects. On the other hand, it may be increased by certain forms of preliminary treatment, such as shot-peening, work-hardening, understressing and certain surface treatments.

From the designer's point of view, while the material to be used may have a limiting stress well above the nominal working stresses, allowance must be made for the adverse effects mentioned above. In particular, calculations should be made to determine the possible stress concentration effects due to sharp corners, changes of section, holes and keyways. Although nominal stresses may be low, much higher local values may exist at such stress-raisers, which could start fatigue cracks and lead to failure.

As an example, consider the shaft shown in Fig. 7. A simple change in section is involved, to accommodate, for instance a bearing. Without any fillet radius, the stress concentration effect at section XX is theoretically infinite. In practice the stress concentration factor would rarely exceed 10, as normal tools would produce a fillet radius of say 0·003-0·004 in. in a nominally sharp corner. With a fillet radius of 0·0625 in., however, the theoretical stress concentration factor becomes 2·3, and with a fillet radius of 0·25 in. it becomes 1·5 (Peterson[2]). The strength reduction factor previously mentioned is usually less than the theoretical stress concentration factor for small components. As size increases, its value approaches the theoretical value. Thus, if design is based on this, a margin of safety is inherently achieved.

It is obvious from the foregoing that generous radii are to be recommended where changes of section occur, and it is essential that thought be given to the matter before specifying small fillet radii for any reason. If it is impossible to increase a fillet radius to a value which will give sufficiently small stress concentration effects, other steps may be taken to reduce the stress-raising nature of the small radius, by introducing relief grooves, and so forth. Several methods of doing this are illustrated in Fig. 8.

In addition to rotating components, the problem of fatigue is, of course, present with any structure subject to vibration or intermittent loading. In this connection it is important to note that stress-raisers of various forms still contribute to premature failure. Welded structures in particular should be designed with this in mind, as they inherently have a lower fatigue strength than the nominal value for the material used. Undercuts, or sharp junctions between weld metal and parent metal, are particularly liable to create local high stress areas. The welding process itself is such that residual stresses are more or less inevitable; where it is known that fatigue conditions are present, it may be beneficial to carry out some form of heat treatment for stress relief purposes.

For welded structures in mild steel it is usual to assume a strength reduction factor of the order of 3 to 6, according to the form of weld. Thus the nominal fatigue limit of ±14 t.s.i. for the unwelded material may be reduced to approximately ±2 t.s.i. under some conditions. Stress relieving of welded parts may improve their fatigue strength by 10-20 per cent.

For general design work, it is useful to remember that most steels have a limiting fatigue stress of about 0·45-0·5 of their ultimate tensile strength at room temperature in a non-corrosive atmosphere. Thus, for example, a 55 t.s.i. ultimate tensile strength steel would have a limiting fatigue

stress of approximately 24-25 t.s.i.

Where it would be uneconomical or impossible to design in such a way that fatigue failure could never occur, as, for example, in the aircraft industry, a *fail-safe* concept has been proposed. This implies that the failure of certain parts by fatigue should not constitute dangerous failure of the whole structure. Similarly, it is quite possible to specify the removal and replacement of a part after the completion of a given number of stress cycles, based on its known fatigue properties.

Conclusion

From what has been said it will be obvious that in most cases it is possible to overcome fatigue by suitable design. It should be emphasised that since so many factors are involved in a fatigue failure, it is essential to make a thorough study of the possibilities at the design stage. In particular, great care must be taken when applying test data obtained under different conditions from those under consideration.

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AN ELECTRONIC COMPUTER SOLVES HYDROSTATIC PROBLEMS

THE effort expended by ship designers using normal mathematical methods to determine the static stability of a ship is measured in man-months, involving as it does an assessment of the weight and location of every component in the ship. These calculations are used to compute the centre of gravity of the ship, which must be at a specified location on the centre-line of the hull. The weight and location of each component and, in certain cases, its dimensions and density are used to calculate its moment about the longitudinal, transverse and vertical reference axes, and these moments and the weights are summed to determine the co-ordinates of the centre of gravity.

Printed Reports

These calculations have now been processed on an IBM 650 computer, with the advantage that printed reports are available in many different classifications. For example, weights must be listed by class of machinery, by system (electrical or steam) and by type of material, while different reports and classifications will be required for Government departments, and for management and technicians within the shipbuilders' organisation. The same basic information on weights and moments is also required for further computer processing of displacement waterline and cross curves of roll stability.

An operator sits at the console of the IBM 650 computer. This is a medium-size unit, capable of some 138,000 logical decisions every minute. It is used for both scientific and commercial work. (Photograph by Guy Gravett.)

In the first of these the hull co-ordinates of some twenty fore-and-aft sections are taken for waterlines at increments of 2 to 4 ft. If required, second-order interpolations between co-ordinates are calculated. The area of each section is computed, multiplied by its length and then summed over the length of the hull. The combinations of component weights and moments with the computed waterline gives the actual waterline of the ship under various load conditions.

In the computation of cross curves of stability, the submerged volume and the location of the centroid for specified waterlines and angles of roll are determined. From these the righting moment of each section is obtained and integrated over the length of the hull to provide the total righting moment for various rolls and waterlines. The location of the centroid of the ship also determines the metacentric height, which is the accepted measure of stability and "feel" of a ship.

The detailed results of the foregoing calculations are summarised to show stability as a function of displacement and other derived data, as a by-product of computer programming.

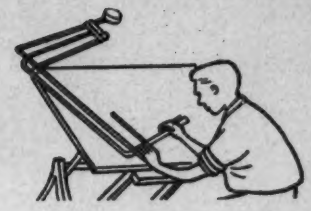
Damage Stability

Problems in hydrostatics also include the computation of damage stability, which is greatly complicated by the very large number of variables and the discontinuous nature of the problem. The equilibrium attitude of the ship must be determined in conditions where one or more compartments are flooded, taking into account the volume of flooded compartments free to be occupied by water. The submergence of decks and superstructure must also be considered. In addition, "floodable length" curves must be computed, showing the length of hull which can be flooded in each section of the ship without exceeding the allowed pitch condition. The manual methods normally employed in these computations cannot be sufficiently searching to produce the optimum solution, and the only economically feasible way of giving due weight to all the variables is by the use of the stored programme computer.

This is true of all hydrostatic problems and, to a lesser extent, of related shipbuilding problems in structural and vibration analysis, and in general design work on heat balance, nuclear shielding and ship motion dynamics.

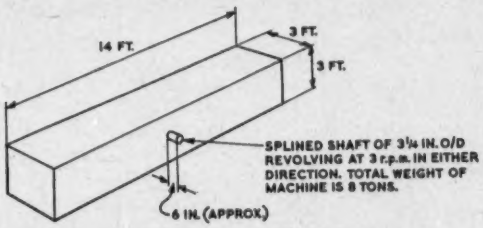
With the increasing use of computers for this type of work, programmes already written and held in the programme library of IBM United Kingdom Ltd. are available for use in similar applications, at a significant saving in time and cost, to produce the only practical means of exploring the effects throughout the structure of minute variations in design.

PROBLEMS IN DESIGN



Problem No. 14 (December): For the testing of a number of special-purpose hydraulically-driven machines of large size, it was necessary to devise a piece of equipment that could absorb a very high torque. Available dynamometers were useless.

A 3½-in.-dia. splined shaft projects about 6 in. from the side of the machine (see diagram). The shaft revolves at 3 r.p.m. in either direction. The load testing device must be capable of absorbing an infinitely variable load, from zero up to a maximum of 6 h.p., for a period of 1 hr.



The energy-absorbing device is necessary to study the behaviour of the machine, in workshop conditions, under quarter, third, half and full load, and, if possible, should not incorporate gears to step up the shaft speed. If gears are used to bring the torque to manageable proportions, the nature of the gearbox must be given. Briefly, the problem is how to absorb so much energy from a shaft revolving so slowly, and at the same time measure the torque.

Entries should provide a good indication of how the problem should be tackled, with appropriate sketches.

In posing this problem, which was sent in by a reader who wishes to remain anonymous, we realised that it was a hard one, and we were not ourselves aware of any easy solution. Although torque measurement in slowly rotating shafts can be arranged with the use of slip rings and strain gauges, or by means of such a device as that described on p. 38 of the January issue, 1961, the problem of absorbing power at such a slow speed, without the use of a step-up gearbox, is formidable by reason of the difficulty of dissipating the heat generated. First thoughts might suggest some sort of friction brake dynamometer, but the torque of 10,500 lb. ft. is exceptionally large, especially if this is to be fed to the dynamometer direct.

To absorb the power hydraulically is also difficult, on account of the large size of the equipment that would be necessary. An electrical dynamometer on the lines used for measuring the output of electric motors would necessitate a d.c. wound stator of very large size, and a co-axial step-up gearbox would certainly be necessary. A set-up on these lines would be very expensive indeed. Moving into the realm of the fanciful, it might be possible to convert the mechanical energy into kinetic energy by making the output shaft lift water from a tank by means of a vertical continuous chain drive carrying buckets, which at the top of its travel caused the buckets to spill their contents, thus dissipating their energy. This would be a large and messy piece of equipment. Stirring a very viscous liquid by a large bladed paddle might form the basis for a dynamometer were it not for the fact that the rise in temperature produced by energy absorption would change the viscosity of the liquid, making torque measurement difficult.

As the number of entries was few, it was decided that the problem be sent to a firm with great experience of power measurement (Heenan & Froude Ltd.) for their comments. This company has kindly sent us their initial reactions to the problem, together with a drawing of the kind of equipment they would consider for the purpose.

As the machine to be tested is a constant-speed device, right up to the point at which it would stall, the test device must incorporate (a) some means of torque measurement, and (b) some means of gradually increasing the load. The main problem is one of power absorption.

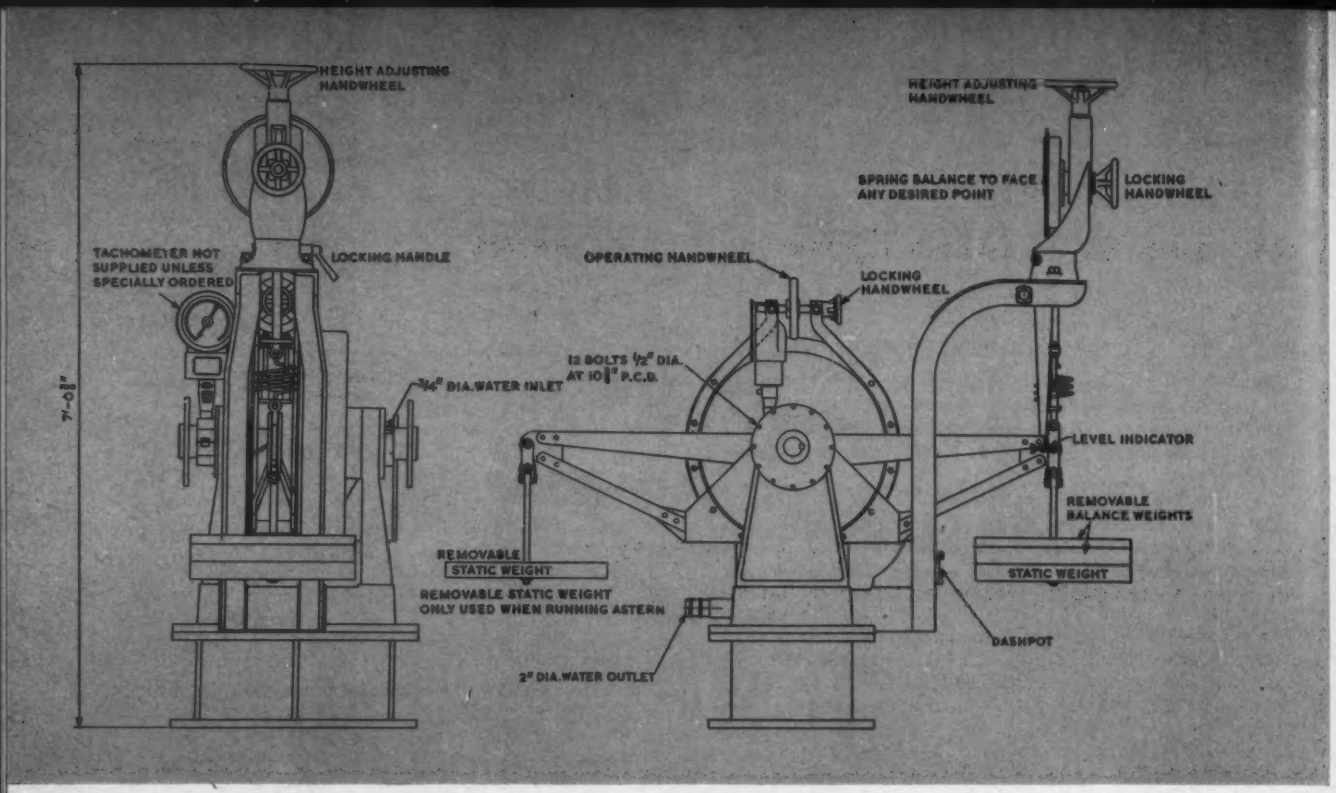
G. C. Barton chose to tackle the problem hydraulically by making the machine drive a large multi-cylinder radial pump, which is shown in diagrammatic form. The pump consists of two side plates *1*, one of which is not shown. Twelve radial trunnion cylinders are pivoted on pins *3* arranged in a pitch circle in the two plates. This circle is concentric with the axis of a sleeve *5* mounted for rotary movement in bearings in the plates *1*. The shaded portion *7* represents the splined shaft of the machine under test, which fits into a splined hole in the component *5*. This component *5* carries an eccentric portion *9* which drives ring members *11* through which pass the pins *13*, arranged in a pitch circle, which secure the piston-rod ends. Each cylinder *19* has an inlet port *21* and an outlet port *23* to which flexible hoses are connected. The inlet connections have non-return valves *25* which prevent oil flow from the cylinders, and the outlet connections have non-return valves *27* which prevent oil flow into the cylinders. All the inlets are connected to a pump delivering oil at low pressure, i.e. 50 p.s.i., and all the outlets are connected to a tank via an adjustable relief valve *37*. The function of the master crank in a radial cylinder engine is served by a plate of triangular shape *29*. This plate is situated on the outside of the two plates *1* which sandwich the cylinders, and is carried on two short links *31* pivoted to it and to extensions of two of the pins *3* which pass through the trunnion ends of two of the cylinders. The third corner of this triangular plate is free to pivot about a spigot extension of the concentric portion of the eccentric *9*.

PROBLEM IN DESIGN No. 18
Here is this month's problem

In a sequence timing device, six microswitches are operated by a small motor-driven timer using a reduction gear. On depressing the motor starter button, each microswitch is operated (on-off) for approximately 1 second, all six switches being operated in one cycle, but not necessarily in the same order. Thus for one programme the order could be 1, 3, 6, 5, 4, 2—for another it could be 6, 1, 3, 2, 4, 5—and so on. At the termination of the cycle, which would be completed in 1 minute, the timer would switch itself off and await the next manual resetting by the operator.

Devise a simple mechanical device to achieve the above conditions. The microswitches can be arranged in a circle or in line as desired.

Best solutions to "Problems in Design" are published and paid for. Send your solution for this month, with a drawing or diagram (in Indian ink and not more than 12 × 12 in., please!), to the Editor, "Problems in Design No. 18 (April)". Closing date March 20.



HEENAN & FROUDE LTD.

Mr. Barton suggests that the plates *1* would be secured to the machine frame by suitable means. During one rotation of the shaft *7*, each cylinder is charged with oil by the pump via the inlet ports *21* and the oil is then expelled through the outlet ports *23* via the relief valve *37*. An efficient oil cooling system must be used with the device. The dimensions suggested are:

Cylinder diameter—2½ in.
Cylinder stroke—3½ in.
Displacement of each cylinder—17·15 cu. in.
Total displacement per rev.—17·15 × 12 = 204·8 cu. in.
Total displacement per min.—204·8 × 3 = 614·4 cu. in.
6 h.p. = 33,000 × 6 = 198,000 ft. lb. of work per min.

$$614{\cdot}4 \text{ cu. in. of oil per min. at 1 p.s.i.} = \frac{614.4}{12} \text{ ft. lb./min.}$$

Pressure setting of relief valve *37* to absorb full output of

$$6 \text{ h.p.} = \frac{198{,}000}{\frac{614.4}{12}} = \frac{198{,}000 \times 12}{614.4}$$

$$= 3{,}865 \text{ p.s.i.}$$

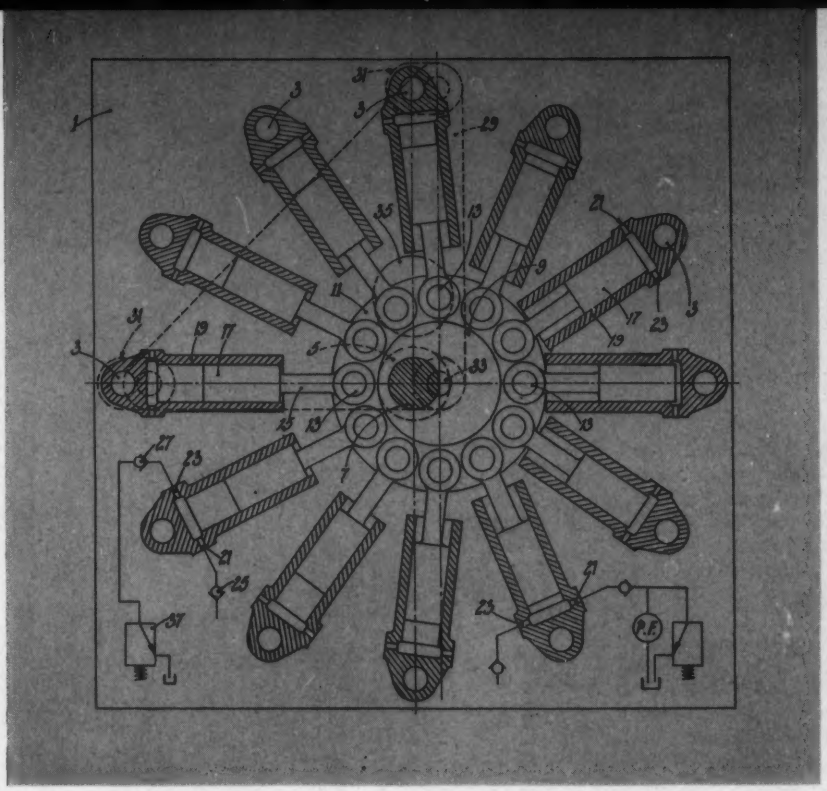
This pressure should be increased by the amount of the inlet pressure, i.e. 50 p.s.i.

No oil seals are shown in the drawing, as it is a diagram only. It is difficult to predict exactly how this pump would work in practice. The pressures seem reasonable. Effectiveness would seem to be dependent upon the extent to which air could be kept out of the system, and the device kept leak-proof. One considerable advantage is that the direction of rotation would be immaterial.

Ewen M'Ewen's idea is particularly novel in that the problem of heat dissipation does not arise. He employs a large multi-bladed Pelton wheel, the blades of which are driven by compressed air. This would seem to be the most practical suggestion coming from any of our readers. Mr. M'Ewen considers that an air pressure of 1,500 p.s.i. would, however, be necessary to enable the machine to be constructed to a reasonable size. It seems to us that water might be a more suitable way to impose a braking torque on the Pelton wheel. Using water, the whole equipment would be positioned over a large tank, suitably boxed in, and a recirculating system employed.

Heenan & Froude Ltd., who have supplied friction brake dynamometers for testing gearboxes having a maximum absorption capacity of 10 h.p. at 40 r.p.m., pointed out that, although such machines would be capable of dealing with 6 h.p. at 24 r.p.m., by increasing the pressure on the shoes for a duty of 6 h.p. at 3 r.p.m. it would be necessary to procure a special gearbox having concentric input and output shafts, arranged in such a way as to speed up the friction brake dynamometer with respect to the machine undergoing test. This speed-increasing gearbox should preferably be mounted in its own trunnion bearings, and any weighing gear attached to the swivelling casing would then react to the difference between the input and output torques.

The drawing shows a Heenan & Froude 24-in. friction brake dynamometer which is equipped with its own independent torque reaction weighing gear. Applied to the problem submitted, the moving casing of the gearbox would be attached or yoked to the swivelling casing of the dynamometer shown on the drawing, and one single set of weighing gear fitted which would react to the input torque on the combination. As an alternative, a very large friction drum, designed for operating at 3 r.p.m., could be designed. It was pointed out, however, that this would be very bulky.



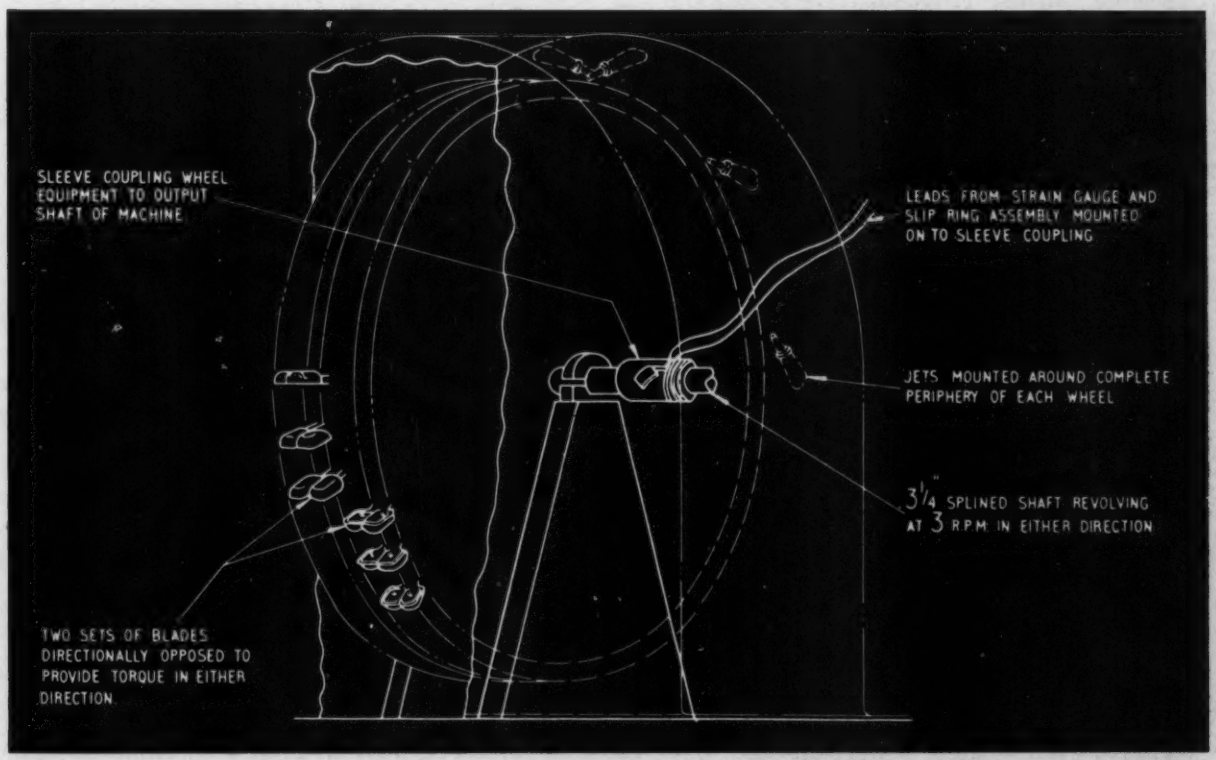
Heenan & Froude Ltd.
(*Far left*) Large Heenan & Froude dynamometer with 24-in.-dia. friction brake.

G. C. Barton
(*Left*) Multi-cylinder hydraulic radial pump with trunnion cylinders mounted between two large side plates.

Ewen M'Ewen
(*Below*) Air-driven Pelton wheel, in which torque measurement is by a strain gauge and slip ring assembly.

G. C. BARTON

EWEN M'EWEN


SLEEVE COUPLING WHEEL EQUIPMENT TO OUTPUT SHAFT OF MACHINE
LEADS FROM STRAIN GAUGE AND SLIP RING ASSEMBLY MOUNTED ON TO SLEEVE COUPLING
JETS MOUNTED AROUND COMPLETE PERIPHERY OF EACH WHEEL
3 1/4" SPLINED SHAFT REVOLVING AT 3 R.P.M. IN EITHER DIRECTION
TWO SETS OF BLADES DIRECTIONALLY OPPOSED TO PROVIDE TORQUE IN EITHER DIRECTION

New Design of Bearing Test Rig

THE group research and development division of Associated Engineering Ltd. has recently designed a bearing test rig for evaluating the coefficient of friction of sleeve bearings made in Deva metal (manufactured by the Universal Metallic Packing Co. Ltd.), under varying load and lubrication conditions. The rig embodies a novel and useful principle.

The problem was to devise a method of determining the value of μ, which can vary over a fairly wide range according to the type of material and lubricant used. The simplest method of obtaining μ for a sleeve bearing is to attach a rigid pendulum to the sleeve and measure deflection from vertical when the journal is rotated. If this deflection equals β degrees, and the radius of the sleeve and the effective length of pendulum are denoted by r and l respectively, then it can easily be shown that the coefficient of friction is given by

$$\mu = \frac{l}{r} \sin \beta.$$

Unfortunately, practical considerations limit the value of the ratio $\frac{l}{r}$ to not much less than 8:1, which means that, for a value of $\mu = 0{\cdot}2$ (the largest estimate for the material under test), the angle will be of the order of only $1\frac{1}{4}°$—an angle which is much too small for practical purposes.

In the new rig the loading weight is split into two, and each half carried at the end of a short moment arm. The angle between the two arms can be adjusted—in the notation of the present set-up, when the two arms are diametrically opposite, the angle between them (α) is taken as zero. Under these circumstances, it is easy to see that there is no righting moment when the "beam" deflects.

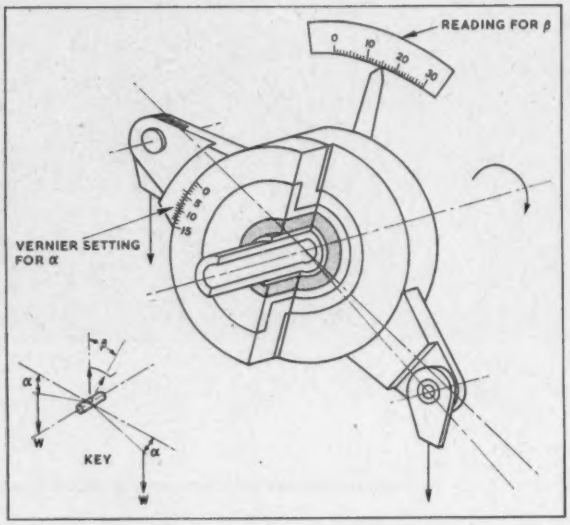
If the arms are now clamped at a small angle to each other a restoring moment on deflection from the mean position is produced, and a simple calculation shows that the value of the bearing friction coefficient is now given by

$$\mu = \frac{l}{r} \sin \alpha \sin \beta,$$

l being now the length of the moment arms, and β, as before, the deflection of the bridge from the mean position. In a typical setting, the angle α would be adjusted before the test to, say, 3°. Under these circumstances, a friction coefficient of 0·2 would produce a bridge deflection of 30°.

The accompanying diagram is a sketch of the bridge mechanism, and the photograph shows the rig set up to test a sleeve bearing $\frac{1}{4}$ in. in dia. The angle α is set by the screw adjustment, and read off by means of a vernier scale, giving a range of 0 to 5°. The small cylinder with an arm attached to one bridge fulcrum is a dashpot, which we have found necessary in some cases.

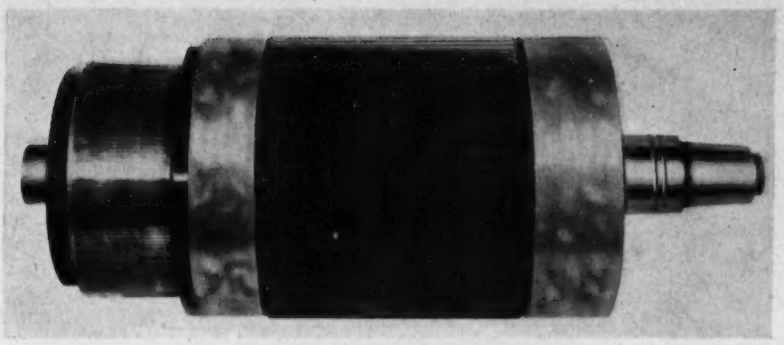
As far as is known, this method of measuring friction coefficient is original.



Sketch of the bridge mechanism.

The right-hand illustration shows the test rig set up for a sleeve bearing.

Submitted by P. R. Smith.



Armature for a D47 traction motor (made by General Motors Corporation).

PART 3 | INSULATION OF WINDINGS FOR TRACTION MACHINES

This final article of a series of three deals with Class H insulation, and describes the design of insulation on armature and field coils for use at temperatures up to 180 deg. C.

by W. DUCKETT

CLASS H

IN Parts 1 and 2 of this series of articles, the insulation recommended by the author has been based on service experience of satisfactory operation over many years, but in dealing with Class H it must be realised that there is less experience in the U.K. with the use of these materials. This is due partly to the high cost of silicone materials, which form an essential part of Class H insulation, and partly to the fact that the manufacturers of machines have not had available the processing plant for dealing with the high temperatures involved with these materials.

Experimental work has been carried out at the Acton Works of the London Transport Executive on a number of LT 100 underground motors which were originally designed in 1937. The object of trying Class H insulation on these machines was to give improved performance and greater reliability.

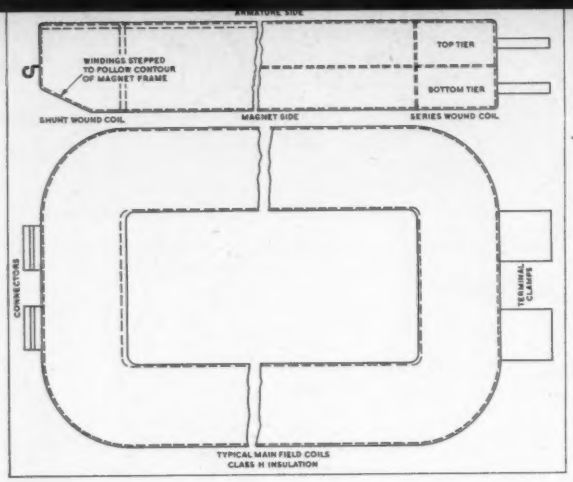
In the U.S.A., the Electro-Motive Division of General Motors Corp. have used Class H materials on the armature and field windings of their latest design of traction motor, and, with improved ventilation, this has resulted in a 28 per cent increase in capacity over the original design (which the author assumes employed either Class B or a combination of Class A and Class B insulation).

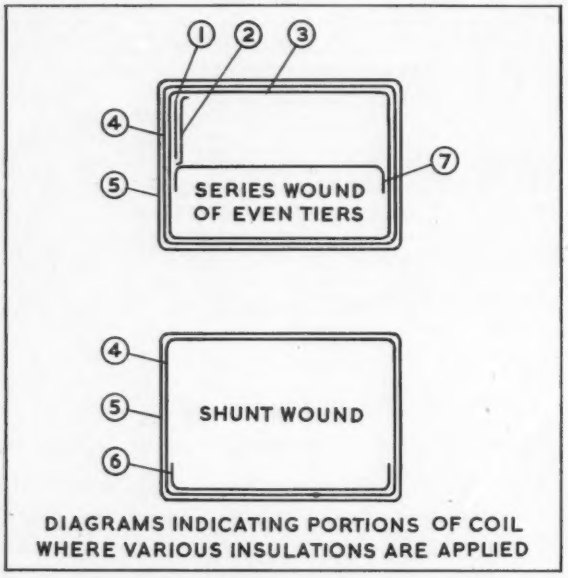
The LT 100 motor mentioned above represented a considerable increase in capacity, by virtue of the incorporation of the fully insulated and pressed field coils mentioned in Part 1 of this article. Therefore, if this type of coil was designed to utilise Class H insulation it can be assumed that an even greater increase in capacity could be achieved. On this assumption the field windings with Class H insulation will be treated in the same way as for Class B and F windings, i.e. pressed to predetermined dimensions. However, in view of the relatively limited experience of Class H materials, the materials and applications mentioned in this article should be taken as recommendations only.

Series Wound Field Coils

Special care should be taken to see that all drying out and baking periods are carried out as recommended, and it should be noted that the periods are longer and the temperatures considerably higher than those required in the manufacture of Class B and Class F windings. If sufficient care is not taken and insulation failures occur, this will be particularly serious owing to the high cost of silicone materials. It should be pointed out that silicone varnishes used must be entirely free from impurities; it is therefore advisable to ensure that all windings are perfectly clean prior to the application of the varnish. It is also recommended that, when not in use, dipping tanks or containers should have tightly fitting covers, to protect the varnish from any dust or foreign matter in the atmosphere.

It is suggested that, if possible, the coils should be designed with tiers of even construction. The individual turns are insulated from each other by means of glass and mica combination, which is built up in sheets consisting of a single layer of mica splittings (preferably supplied in book form) which are protected on both sides with 0·002-in.-thick woven glass cloth. Silicone varnish is used for the bonding of the two materials. In applying the interleaf insulation between the turns of the copper conductor, it can be attached to the strip at frequent intervals, with a minute application of MS 996 silicone varnish to avoid displacement during the winding operation. After completing the winding and fitting of terminal clamps to their respective conductor ends, a glass and mica combination sheet cut to shape sufficiently large enough to overlap the edges is inserted between the tiers. The built-up mica com-





DIAGRAMS INDICATING PORTIONS OF COIL WHERE VARIOUS INSULATIONS ARE APPLIED

1. BARE COPPER CONDUCTOR
2. GLASS AND MICA COMBINATION
3. WOVEN GLASS TAPE
4. SILICONE ELASTOMER COATED GLASS
5. WOVEN GLASS TAPE
6. GLASS AND MICA COMBINATION
7. GLASS AND MICA COMBINATION

bination sheet is made from three layers of mica splittings (book form), the separate layers being bonded to each other with MS 996 silicone varnish and protected on both sides with 0·002 in. woven glass cloth, MS 996 again being used for bonding.

To avoid movement of the winding during the subsequent operations, the coil should be given a tight open spiral wrap of $\frac{1}{4} \times 0{\cdot}007$ in. thick woven glass tape. The coils are then placed in an oven for not less than 3 hr. at 150 deg. C.; this drying-out period is essential to drive off the solvents from the varnish used in the bonding of the interleaf insulation.

After drying out, the insulation to earth is applied. For machines up to and including 750 V., one half-lap layer of silicone elastomer-coated glass is used; from 800 to 1,500 V., two half-lap layers are necessary; above this voltage, further half-lap layers must be added, varying according to the voltage. Before applying the silicone insulation it is important to ensure that the winding is perfectly clean and free from dust or foreign matter, and that the operation takes place in a clean, dry atmosphere, to avoid dust or moisture adhering to the silicone side of the tape, which should be applied adjacent to the coil. To facilitate the application of the tape, it is supplied wider than is usually manufactured for general use, and consequently it is advisable for the operator to cut it away during application at the four corners of a rectangular coil (or at both ends of a semi-circular-ended coil), to avoid the insulation building up to an unnecessary thickness. Following the application of the earth insulation, the coil is finally covered with a special woven glass tape 0·01 in. thick. As stated in Part 1, this is specially woven with an increased number of warp and weft threads per inch than that in general use—this allows for more varnish to be retained after application, either in a dipping or brushing operation. The taping is applied butt joint, which automatically develops into a half-lap application at the four corners of a rectangular coil, or at both ends of a semi-circular-ended coil.

During the pressing operation, all the insulating materials, with the exception of the mica, undergo compression. Practically the whole of this insulation is of woven glass fibre; consequently, only 1 per cent of the total thickness is allowed to take place. This does, however, ensure that minimum dimensions are obtained, and at the same time eliminates air pockets that may exist due to the handling of the insulation. A typical example for obtaining these dimensions is illustrated on page 223.

Before the pressing operation, the gear (a typical example of which is illustrated in Part 1) should be preheated to 70 deg. C. Immediately after heating, the mild steel centre block provided with a smooth finish is inserted in the coil centre, and the complete gear, with one or more coils in position, is assembled. The coils are subjected to pressure on the top and bottom sides, and also along the longitudinal sides where space is limited to allow for the maximum amount of air flow between adjacent coils when mounted. The pressure results in smooth surfaces, which facilitates the removal of foreign matter such as brake dust, which tends to accumulate whilst the machines are operating in service.

After removal from the press, the assembled unit with coils in position is baked for 15 min. at 150 deg. C. to drive off any solvents or moisture. After removal from the oven, the unit is allowed to cool to ambient temperature before it is dismantled and the coils extracted. The coils are then hung vertically with the terminal clamps uppermost and baked for 4 hr. at 200 deg. C., taking special care that the coil itself reaches the specified temperature before the 4-hr. period is deemed to commence.

After removal from the oven, when the temperature of the coils has dropped to approx. 70 deg. C., they are immersed in Megasil 1400 varnish until air bubbles have ceased to rise. After immersion, all surplus varnish is carefully removed, and they are allowed to drain in a vertical position for 30 min.

They are now finally baked for 4 hr. at 200 deg. C., again making sure that the coils register the specified temperature before the period commences. If the coils are to be stored, it is advisable to wrap the whole of the terminal clamps, up to the face of the coil, with a protective cotton tape, the rolls of which have been impregnated in a melted silicone grease to prevent any accumulation of moisture (particularly on the contact surfaces). They should be kept in a cool dry place until ready for mounting in the magnet frame.

Shunt Field Coils

Regarding the shunt wound field coils, the conductor is made from high-conductivity round copper wire insulated with two lappings of glass fibre impregnated with a silicone varnish. Before commencing the winding operation, the soft double-annealed copper strip leading to the terminal point is soldered to the starting end of the conductor, using a high-melting-point solder. The connector is insulated with a half-lap layer of glass and mica combination cut from sheets built up of two layers of mica splittings (book form), the layers being bonded to each other with silicone MS 996

Method for Obtaining Predetermined Dimensions on Field Coils with Class H Insulation (all dimensions in inches).

Copper—no compression.
Glass Fibre (Packing)—no compression.
Woven Glass Tape—0·007 thick, after 1 per cent compression = 0·0069.
Woven Glass Tape—0·01 thick, after compression = 0·0099.

Interleaf—

0·002	glass cloth.
0·0015	mica.
0·002	glass cloth.
0·0015	varnish.
0·001	allowance for building.
0·008	(after 1 per cent compression = 0·0079).

Separators and Armature Core Insulation—

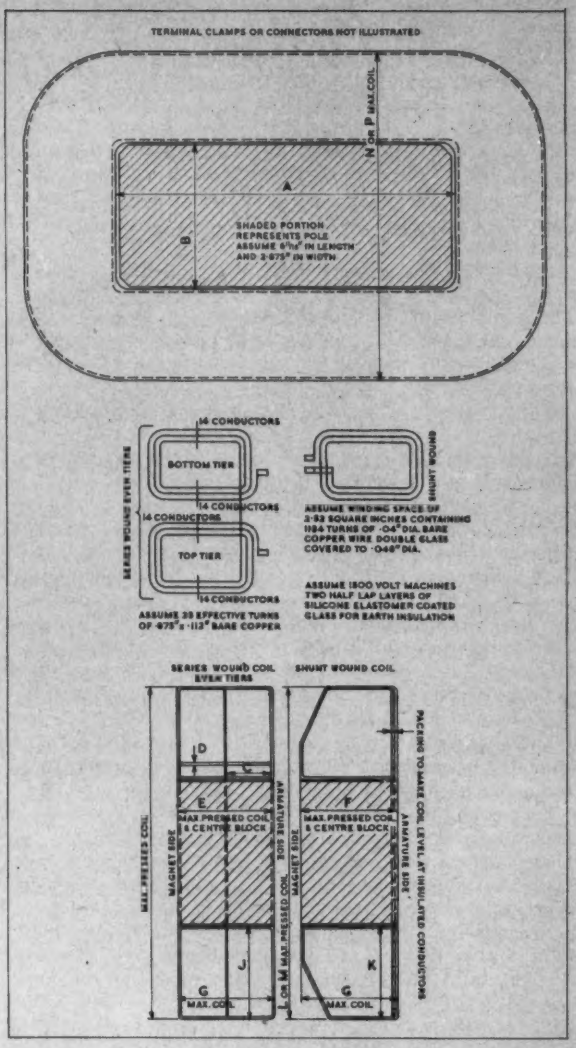
0·002	glass cloth.
0·0045	mica.
0·002	glass cloth.
0·0015	varnish.
0·0015	allowance for building.
0·0115	(after 1 per cent compression = 0·0114).

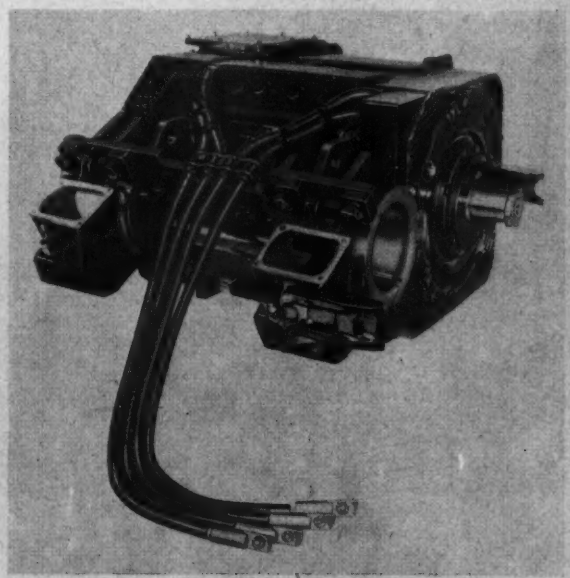
Silicone Elastomer Coated Glass—0·015 thick, after 1 per cent compression = 0·0148.

A centre block length = length of pole + 0·2.
B centre block width = width of pole + 0·07.
C conductor depth.
D conductor thickness.
E (**G** × 2) + compressed insulation thickness.
F winding depth + compressed insulation thickness + packing.
G **E** + 0·016, or **F** + 0·016 (final coating of varnish).
H number of conductors
J (**H** × **D**) + (**H** − 1 × 0·0079) + insulation thickness.
K winding width + insulation thickness.
L **B** + (**J** × 2).
M **B** + (**K** × 2).
N **L** + 0·016 (final coating of varnish).
P **M** + 0·016 (final coating of varnish).

Series Wound Coil, Even Tiers
E = 0·875 × 2 + 0·243 = 1·993.
G = 1·993 + 0·016 = 2·009.
L = 2·945 + 3·691 = 6·636.
N = 6·636 + 0·016 = 6·652.

Shunt Wound Coil
F = 1·68 + 0·229 + 0·08 = 1·989.
G = 1·989 + 0·016 = 2·005.
M = 2·945 + 3·691 = 6·636.
P = 6·636 + 0·016 = 6·652.
(All calculations are based on insulation thickness after 1 per cent comparison.)


TERMINAL CLAMPS OR CONNECTORS NOT ILLUSTRATED
N OR P MAX. COIL
A
B
SHADED PORTION REPRESENTS POLE ASSUME 6⅞" IN LENGTH AND 2·675" IN WIDTH
14 CONDUCTORS
BOTTOM TIER
14 CONDUCTORS
14 CONDUCTORS
TOP TIER
14 CONDUCTORS
SERIES WOUND EVEN TIERS
SHUNT WINDING
ASSUME WINDING SPACE OF 2·93 SQUARE INCHES CONTAINING 1184 TURNS OF ·04" DIA. BARE COPPER WIRE DOUBLE GLASS COVERED TO ·048" DIA.
ASSUME 1500 VOLT MACHINES TWO HALF LAP LAYERS OF SILICONE ELASTOMER COATED GLASS FOR EARTH INSULATION
ASSUME 20 EFFECTIVE TURNS OF ·675" × ·113" BARE COPPER
SERIES WOUND COIL EVEN TIERS
SHUNT WOUND COIL
D
E
F
MAX. PRESSED COIL & CENTRE BLOCK
MAX. PRESSED COIL & CENTRE BLOCK
MAX. PRESSED COIL
MAGNET SIDE
ARMATURE SIDE
MAX. PRESSED COIL
MAGNET SIDE
ARMATURE SIDE
PACKING TO MAKE COIL FIT AT FINISH GOOD CONDITION
J
K
G
MAX. COIL
L OR M MAX. PRESSED COIL
G
MAX. COIL



D47 traction motor wound with Class H insulation (General Motors Corporation).

varnish and protected on both sides with woven glass cloth 0·002 in. thick, the same varnish being used for bonding.

During the winding operation each layer is brushed with Megasil 1400 varnish. At the commencement of the winding a piece of flexible mica occupying the full depth of the coil is inserted between the first four or five layers at the four corners of a rectangular coil, or at both ends of a semi-circular-ended coil. This insulation provides a reinforcement where the fibres of the covering over the conductor tend to open due to the small radii. To facilitate in ensuring a rigid connection, before applying the last three or four layers of the winding it is advisable to insert the insulated copper strip leading to the terminal point at the end of the winding. The insulation of the copper connector is identical to that applied at the starting end. When the winding operation is completed the connector is soldered to the end of the conductor.

The metal side plates, which occupy the full length and depth of the coil for the subsequent baking operation, are smeared with silicone grease and firmly clamped in position. The unit is now baked for 4 hr. at 200 deg. C. After baking, and before removing the side plates, the unit is allowed to cool to ambient temperature. The side plates are then removed, and any surplus varnish is carefully brushed away.

The connectors from the start and finish of the winding are now drifted and formed to their respective positions. During this operation a sheet of mica combination is inserted between the connectors and remainder of the coil. This mica combination is made up from two layers of mica splittings protected on both sides with woven glass cloth, MS 996 varnish being used for bonding. The contact surfaces of the connectors are wrapped with cotton superfine tape which has been treated with silicone grease, to protect them during the subsequent operations.

To make the coil level prior to the application of the outer insulation, glass fibre board of sufficient thickness to coincide with the depth taken up by the insulated connectors is placed along the armature side, and the packing cut away at the portion where they lie in position. Woven glass cloth, three layers of mica splittings, and woven glass cloth bonded with silicone MS 996 varnish, are cut to shape to fold ½ in. down all sides, and placed on the magnet side. The main insulation to earth is now applied, consisting of the same materials and amounts as those on the series wound field coil.

Shunt wound field coils can also be manufactured to predetermined dimensions, the formula being identical to that given in Part 2, relating to a Class F shunt coil which employs a round covered conductor, i.e. $\frac{1}{\text{dia.}} \times \frac{1{\cdot}08}{\text{dia.}}$ turns per sq. in. Again, taking the example of a copper conductor, 0·04 in. dia. bare plus 0·008 in. for the total thickness of covering equals 0·048 in. overall diameter= 470 turns per sq. in. A typical example for obtaining the predetermined dimensions of the complete coil is illustrated on page 223.

Armature Coils

The majority of machines with Class H insulation operating on diesel-electric locomotives in the U.S.A. employ single-turn armature coils. As already stated, this third part of the article relates to this type of winding.

Where the coils are made in the form of a bar, they are connected at the back end (remote from the commutator) after mounting. In such cases it is necessary to provide a small radius at the corners of the copper strip, to avoid possible damage to the insulation during its application. The majority of coils, however, are formed with an evolute at the back end. As the insulation is identical in both cases, this article is confined to the latter form, where the copper strip is made with a semi-circular edge.

The number of conductors comprising a coil are formed to shape to coincide with the armature coil supports on which they are to be mounted. The conductors are insulated from each other by 0·003-in.-thick specially woven glass tape, the rolls of which have been previously impregnated in silicone MS 997 varnish. For this operation the rolls and the varnish should be at ambient temperature. The rolls are suspended on twine which has been threaded through the centres, and immersed in the varnish for a period of not less than 10 min. On removal from the container they are allowed to drain thoroughly, after which they are suspended in an oven for 2 hr. at a temperature not exceeding 100 deg. C., otherwise the tape is liable to become hard, and impair a tight application. The taping is applied ¼ lap (just overlapping) to each bare conductor from end to end of the coil.

Separators cut from silicone varnished glass cloth are inserted between the conductors at the evolute, where they have been formed round the hair-pin bend. These separators are cut to a U shape, and made to occupy the full depth of the top and bottom legs. To avoid any displacement on the assembled insulated conductors during subsequent operations, it is advisable to apply a permanent spiral wrap of ½ × 0·003 in. woven glass tape from end to end. The coils are now temporarily wrapped from end to end with a cotton superfine tape (applied butt joint), the rolls of which have been impregnated in a melted silicone grease or lubricant to facilitate removal at a later stage.

The prepared coils are now subjected to a pressing along the straight portion. For this operation mild steel blocks are preheated to 180 deg. C. On reaching this temperature, the grooved surfaces which have been made to fit the straight portion of the coils are quickly brushed with a silicone grease, and while hot the coil is inserted. Pressure is then applied until the top and bottom halves register and the cotter pins are tightened. A typical pressing block for this operation is illustrated in Part 1.

It is very important that the assembly of coil and blocks is allowed to cool to ambient temperature before removing the cotter pins and extracting the coils. The temporary wrapping of superfine tape is then removed, and the coil wrapped from end to end with a half-lap application of ½ × 0·003 in. woven glass tape, the rolls of which have been treated with silicone MS 997 varnish.

The main insulation to earth is now applied, and occupies the full length of the straight portion. On machines up to and including 750 V., this insulation consists of two wrappings of three layers of mica splittings bonded with MS 996 varnish, in conjunction with two wrappings of Melinex. Although this material is not Class H, in conjunction with mica splittings it will be found suitable to meet Class H requirements. On machines from 800 to 1,500 V., three wrappings are applied; above 1,500 V. it is necessary to apply a minimum of four wrappings of the two materials. The wrappings are cut into rectangular pieces of sufficient dimensions to provide an overlap on the top side of each leg. The Melinex should be cut slightly wider than the splittings, so as to project beyond the mica on completion of the application.

The coils are now covered from end to end with a butt joint of ½ × 0·007 in. woven glass tape, the rolls of which have been previously impregnated in MS 997 varnish. This tape is specially woven with a greater number of warp and weft threads per inch to that generally manufactured for general use.

The straight portions are now brushed with Megasil 1400 varnish, and dried out for a period of 2 hr. at 110 deg. C., special care being taken that the temperature and period are not exceeded. The straight portion is now subjected to a second pressing, during which it is manufactured to predetermined dimensions. A typical example is illustrated separately on page 226. The slots of the armature laminations are manufactured to tolerances of −0·000 +0·004 in.

in depth and −0·000 +0·003 in. in width.

For the final pressing operation mild steel pressing blocks are employed. In other respects the final pressing operation is carried out in the same way as the first pressing.

As stated in Part 2, woven glass is susceptible to fracture. Consequently, if the coils are to be stored it is advisable to wrap the end winding at the back end (evolute) with cotton superfine tape which has been impregnated in a melted silicone grease. It is also advisable to cover the projecting bare conductors completely at the commutator end with the same material, to prevent moisture from the prevailing atmosphere, or foreign matter, accumulating on the commutator leads.

Winding Supports

Before the mounting operation, the insulation to earth is applied round the periphery of the armature winding supports. This is cut into sufficient lengths and widths to enable the operator to effect a tight application. The strips are cut from sheets made up from three layers of mica splittings bonded to each other with MS 996 silicone varnish, and protected on both sides with 0·002-in. woven glass cloth, MS 996 again being used for bonding. It is very important that the edges overlap, to avoid possible creepage between the winding supports and the armature conductors. They are held in position by the application of a high-grade woven glass tape having a nominal thickness of 0·005 in., the rolls of which have been previously impregnated in silicone MS 997 varnish.

To eliminate the possibility of creepage due to an accumulation of metallic dust between the edge of the armature core and the end windings, MS 997 silicone varnish is applied down the outside face, to the full depth of each tooth in the thick end plates (armature laminations), at each end of the armature core.

MS 997 is also applied over the periphery of the insulated coil supports, extending approximately $\frac{1}{4}$ in. from the edge of the core at each end. Insulating cement is then applied between the projecting Micanite separators on the commutator. This cement is made up of approximately two parts of asbestos powder to one part of mica dust, sufficient MS 996 varnish being added to the two materials to form a stiff paste.

Also, after mounting five or six coils, layers of woven glass and mica combination (identical material to that applied on the winding supports) are applied to the upper surfaces of the mounted bottom legs at both ends of the armature core, i.e. the end windings. Sufficient layers are applied to fill the space between the top and bottom legs when mounted.

Following the mounting operation of the bottom legs, before each top leg is mounted, a glass and mica combination separator (identical material to that applied on the winding supports) is placed along the full length of the armature core, in each slot.

After temporary bonding has been applied and the commutator soldered, the armature is baked for 1 hr. at 200 deg. C. After cooling, MS 997 silicone varnish is applied to the front end (commutator) from the edge of the commutator to the end of the commutator ring. The insulation on the commutator end winding is now applied, consisting of three layers of mica splittings and woven glass combination held in position by 0·005-in. woven glass tape, the rolls of which have been impregnated in MSS 997 silicone varnish. This insulation is reinforced and protected from the steel bands by the application of pieces of hard mica to the complete periphery of the armature, these being held in position by woven glass tape.

The temporary banding is now removed from the back end winding, and the insulation prior to the final banding is applied using the same materials as employed at the commutator end. Woven glass tape 1 × 0·005 in., treated with MS 997 silicone varnish, is applied to the front commutator V ring.

For the final band, steel wire is applied, the diameter varying according to the peripheral speed of the armature. At this point it should be stated that the Electro-Motive Division of General Motors, on their latest D 47 traction motor, and also the London Transport on their experimental LT 100 machine, are employing polyester glass tape in place of steel wire at the back and commutator ends of the armature. A number of layers of this glass tape is

Manufacturers and suppliers of copper and insulating materials

Material	*Purpose*	*Recommended Suppliers*
Soft double-annealed copper strip	Conductors on armature and field windings	Thomas Bolton & Sons Ltd.
High-conductivity round copper wire, double glass covered	Conductors on shunt field and multi-turn armature windings	Pirelli-General Cable Works Ltd.
Soft double-annealed copper strip lap or braided glass covered	Conductors on two-turn armature windings	London Electric Wire Co. & Smiths Ltd.
Book form mica splittings	Building mica combination	Micanite & Insulators Co. Ltd.
Hard mica	Winding supports and banding insulation	Micanite & Insulators Co. Ltd
Red rope paper	Building field coil interleaf insulation	Attwater & Sons Ltd.
Glazed transparent parchment paper	Applied to windings and pressing gear to avoid sticking	Attwater & Sons Ltd.
Jap tissue paper	Building mica combination	Attwater & Sons Ltd.
Shellac varnish	Bonding in building mica combination	Jenson & Nicholson Ltd.
Unimpregnated woven asbestos tape	Overall covering on windings	Turner Brothers Asbestos Co. Ltd.
Natural brown synthetic resin varnish	Bakelising treatment on windings	Attwater & Sons Ltd.
Heat resisting enamel (Meggerlac)	Final coating on windings	Pinchin, Johnson & Co.
Clear extra-flexible mica sticking varnish	Bonding in building mica combination	Pinchin, Johnson & Co.
Woven glass cloth	Building mica combination	Marglass Ltd.
Specially woven glass tape	Insulating taping on windings	Jones, Stroud & Co. Ltd.
High-grade baking varnish	Impregnating windings and treatment of woven tapes	Lewis Berger (Great Britain) Ltd.
Anti-tracking enamel	Armature core and commutator V-rings	Lewis Berger (Great Britain) Ltd.
Micanite separators	Insulation between commutator bars	Micanite & Insulators Co. Ltd.
Micanite V-rings	Commutator	Micanite & Insulators Co. Ltd.
Ethoxoline varnished glass cloth	Interleaf on field coils and earth insulation	Micanite & Insulators Co. Ltd.
Asbestos paper	Interleaf insulation on field coils	Turner Brothers Asbestos Co. Ltd.
Polyester glass tape	Replacing steel wire for banding	Insulating Sleevings & Tapes Ltd.
Silicone varnishes	Manufacture of armature and field coils and impregnation of armatures	Midland Silicones Ltd.
Silicone varnished glass cloth	Earth insulation	Micanite & Insulators Co. Ltd.
Epoxy varnished glass cloth	Earth insulation	loco Ltd.
Silicone elastomer coated glass	Earth insulation for field coils	H. D. Symons & Co. Ltd.

Method for Obtaining Predetermined Dimensions on Single-turn Armature Coils with Class H insulation (all dimensions in inches).

Assume 800-1,500 *V., five coils per slot, with a conductor of* 0·550 × 0·045 *in. bare.*

27. bare conductor.
28. treated woven glass tape along conductors.
29. treated woven glass tape (to avoid movement).
30. wrappings along straight portion.
31. treated woven glass tape (coil overall).
32. treated woven glass tape (final covering).
33. superfine cotton tape (temporary) removed after pressing.

28.
29. 0·003 Treated Woven Glass Tape—after 1 per cent compression = 0·0029.
31.

30. Separate Wrappings in Conjunction with Each Other—
    0·0055 mica and bonding varnish.
    0·001 Melinex.
    0·0065 (after 1 per cent compression = 0·0064)
32. 0·007 Treated Woven Glass Tape—after 1 per cent compression = 0·0069.
33. 0·0065 Superfine Cotton Tape—after 1 per cent compression = 0·0064.

First Pressing Depth—

1 × 0·5500 = 0·5500	(bare copper)	27
4 × 0·0029 = 0·0116		28
2 × 0·0029 = 0·0058		29
2 × 0·0064 = 0·0128		33
0·5802	(before removal of 33)	
= 0·5802 − 0·0128 = 0·5674	(after removal of 33)	

Second Pressing Depth—

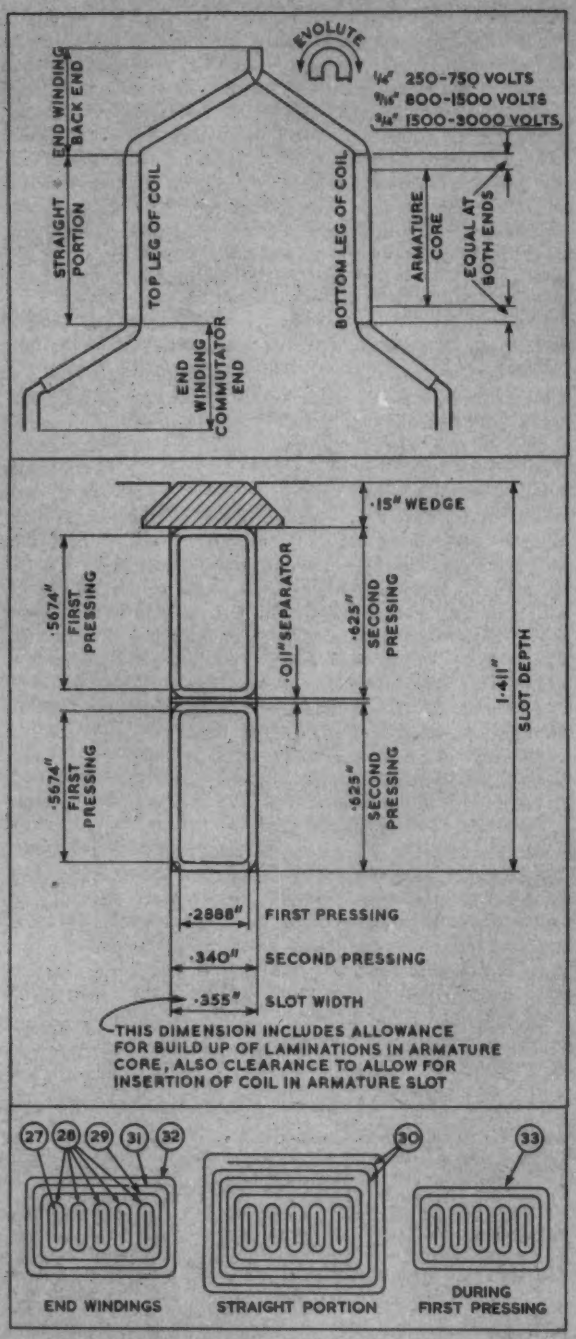
4 × 0·0029 = 0·0116		31
5 × 0·0064 − 0·0320		30
2 × 0·0069 = 0·0138		33
0·0574	(compressed insulation)	
Coil after first pressing = 0·5674		
Compressed insulation = 0·0574		
0·6248	(say 0·625)	

First Pressing Width—

5 × 0·045 = 0·2250	(bare copper)	27
20 × 0·0029 = 0·0580		28
2 × 0·0029 = 0·0058		29
2 × 0·0064 = 0·0128		33
0·3016	(before removal of 33)	
= 0·3016 − 0·0128 = 0·2888	(after removal of 33)	

Second Pressing Width—

4 × 0·0029 = 0·0116		31
4 × 0·0064 = 0·0256		30
2 × 0·0069 = 0·0138		33
0·0510	(compressed insulation)	
Coil after first pressing 0·2888		
Compressed insulation 0·0510		
0·3398	(say 0·340)	



Slot Depth—
0·150 armature slot wedge.
0·625 coil depth, top leg.
0·011 separator.
0·625 coil depth, bottom leg.
1·411

Slot Width—
0·340 width of coil.
0·010 build up of armature laminations.
0·005 clearance.
0·355

claimed to be stronger than the steel banding wire, provided that the resin is adequately cured. A further advantage of this material is that it is unaffected by a flash over.

The armature is then baked for 4 hr. at 200 deg. C. After this, when the temperature has dropped to approximately 70 deg. C., silicone varnish MS 997 is applied to the complete armature from the commutator lugs to the evolute at the back end; it is also applied to the front commutator V ring. The armature is then allowed to drain in a vertical position for not less than 30 min., thus removing all surplus varnish.

The armature is then baked again for a further period of 6 hr. at 200 deg. C. After baking, when the temperature has dropped to 70 deg. C., Megasil 1400 varnish is applied to the complete armature, including the front commutator V ring. After draining thoroughly for at least 30 min., during which period all surplus varnish is removed, the armature is finally baked for 4 hr. at 200 deg. C. If the armatures are to be stored, they should be covered and kept in a cool, dry place.

SAMICA INSULATION

SAMICA is a paper-like material composed entirely of mica. It is produced by a process invented by the French scientist M. Jacques Bardet, who found that, after controlled heating and chemical processing, mica could be broken up into small platelets which gave a thin coherent film on filtration from an aqueous dispersion. The process has been developed to the stage whereby a modified paper-making machine is used to produce continuous lengths of mica paper. Made by this process the material is 100 per cent mica, and is known as Samica (The Micanite & Insulators Co. Ltd.).

Mica has been used since the beginning of the electrical industry because of its excellent insulating properties, e.g. high dielectric strength, low power factor and good resistance to corona and heat. It is mainly used in the form of Micanite, which is a composite insulating material made by cementing mica splittings with a suitable resin and using a reinforcing material such as paper or fabric where thin flexible materials are required. A similar range of materials can be made from Samica, the treated material being known as Samicanite. By virtue of the uniformity of Samica and the ease with which it may be impregnated, Samicanite is much more uniform both in thickness and in physical properties than is possible with Micanite.

The physical properties of Samicanite depend largely on the resin used for impregnation. Flexible resins such as alkyd, polyurethane and silicone are used to manufacture tapes and sheet materials for wrapping coils, bars, etc. Usually a thin glass cloth is incorporated to give the mechanical strength required during wrapping operations.

Samica can also be impregnated with thermosetting resins such as epoxides and silicones, so that the impregnated stock can be consolidated by pressing or moulding to give a variety of rigid products such as boards, tubes, commutator V-rings, etc. Some of these thermosetting resins can also be used in tapes and flexible Samicanite, so that a rigid insulation can be produced after wrapping by consolidation under heat and pressure.

The outstanding advantage of the wide range of insulating products produced from Samica is the higher degree of uniformity than has previously been possible with micaceous insulation.

HIGH-TEMPERATURE STEELS

AN investigation* to develop steels having a combination of very high strength at ambient temperature and at temperatures approaching 650 deg. C. has shown that, with proper balancing of the composition and optimum heat-treatment, this objective can be attained. At temperatures up to 593 deg. C., the steels developed under this project had higher strengths than any other steel known today. The highest strengths were obtained on steels that contained C, 0·35-0·40; Cr, 7-9; V, 0·5-1·0; Mo, 5-7; Co, 5-8; Ti, up to 1; Ta + Cb, up to 1; W, up to 1·5; and B, up to 0·01 per cent. For example, one steel that contained C, 0·36; Cr, 7·72; V, 1·15; Mo, 5·71; Co, 4·93; and B, 0·009 per cent had a tensile strength of 310,000 p.s.i. at room temperature and 201,000 p.s.i. at 593 deg. C.—the 100-hr. creep-rupture strength at 593 deg. C. was 98,000 p.s.i. Excellent strengths were also obtained at 650 deg. C. In some cases, beneficial effects on strength and ductility were derived from using a novel heat-treating schedule. Studies indicated that the fracture behaviour and the creep-rupture strength were significantly influenced by the formation and coalescence of carbides at the grain boundaries.

It is well known that some existing martensitic steels offer outstandingly high strengths at ambient temperature and at temperatures up to about 537 deg. C. Unfortunately, as the temperature is increased above about 537 deg. C., these steels lose their strengths precipitously, so for service at temperatures above about 593 deg. C. as a rule austenitic steels and superalloys are used.

However, the austenitic steels and superalloys are inferior to the martensitic (ferritic) steels with regard to some other important design criteria. For example, austenitic steels have a significantly lower room-temperature strength, a higher coefficient of thermal expansion, a lower thermal conductivity and a lower damping than martensitic steels.

This research project was initiated to extend the upper temperature limit of applicability of the martensitic steels toward 650 deg. C., such steels being of importance in airframe structures and engine components operating at temperatures up to this temperature. In general, the steels that had the highest values gave at room temperature: 0·2 per cent offset yield strengths up to 280,000 p.s.i., tensile strengths up to 332,000 p.s.i., elongations up to 10 per cent, and reductions of area up to 33 per cent. The results were obtained after austenitising at 1,150 deg. C. and tempering at 593 deg. C. for 2 + 2 hr. In most cases, the notched-to-unnotched tensile strength ratios were less than unity. At 593 deg. C. the steels had 0·2 per cent offset yield strengths up to 166,000 p.s.i., tensile strengths up to 201,000 p.s.i., and elongations up to 25 per cent.

At 593 deg. C. 100-hr. creep-rupture strengths of 90,000 to 100,000 p.s.i. were obtained on several steels after austenitising at 1,150 deg. C. and tempering at 593 deg. C. for 2 + 2 hr. Increasing the austenitising temperature tended to enhance the creep-rupture strength, but, in many instances, significantly reduced the ductility. At 650 deg. C. several steels gave 100-hr. creep-rupture strengths of about 35,000 p.s.i. or greater. In some instances, isothermal treatments given immediately after the austenitising treatment improved both the creep-rupture strength and ductility of the steels at 593 deg. C.

Isochronous stress-strain curves at 593 deg. C. were obtained on three steels in this investigation. The creep strengths of these steels were higher at 593 deg. C. than that of the strongest available hot-work steel at 537 deg. C., and that of the strongest available precipitation-hardenable stainless steel at 482 deg. C.

* *"Development of High-temperature Iron-base Alloys", WADC Technical Report No. 59-353.*

SURVEY OF HYDRAULIC ACTUATORS

PART 2

This concluding section of the survey completes the list of principal manufacturers and suppliers of hydraulic actuators

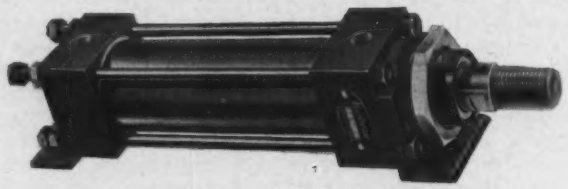
by J. A. COATES

Marrel-Hydro

(*distributed by Aero Maintenance Equipment Ltd.*)

In addition to jacks to special order, a standard range of diameters is available with working strokes up to a maximum of 20 ft. for the larger units. Cylinder diameters range from 49 to 200 mm. (1·89 to 7·875 in.), and various piston rod diameters are available for each cylinder. The standard range of jacks is suitable for working pressures up to 5,000 p.s.i., while special jacks can be supplied for pressures up to 7,000 p.s.i. The mounting styles of the standard range are the centre pivot (F), front flange (C) and rear pivot (G). The ends of the piston rods are externally threaded to accommodate whichever end fitting is appropriate to the application.

Martonair Ltd.



Typical Martonair hydraulic cylinder.

* Indicates a 5 t.p.i.
† No 4-in.-dia. piston rod model is available in 10 and 12 in. dia. cylinders.
‡ Style E is not available in 10 and 12 in. dia. cylinders.
Strokes to order.

Double-acting cylinders (adjustable cushioning at both ends)

Bore (in.)	Standard port (B.S.P.)	Piston rod dia. (in.)	Piston rod end styles available (B.S.F.)			Mounting styles
			Internal	External (full thread)	External (shouldered)	
2	¼	1	⅜	1	⅞	A, C, D, E†‡, F, G and J. Rear† and front hinge, and tie rod mountings.
2½	⅜	1	⅜	1	⅞	
2½	⅜	1¼	1	1¼	1	
3	¼	1	¾	1	⅞	
3	½	1¼	1	1¼	1	
4	½	1¼	1	1¼	1	
4	½	1½	1¼	1½	1¼	
5	½	1¼	1	1¼	1	
5	½	1½	1¼	1½	1¼	
6	¾	1½	1½	1½	1½	
6	¾	2½	1½	2½	2	
8	1	1½	1½	1½	1½	
8	1	2½	1½	2½	2	
8	1	3	2½	3	2½	
10	1	2½	1½	2½	2	
10	1	3	2½	3	2½	
10	1	4	3½*	4*	3½*	
12	1	2½	1½	2½	2	
12	1	3	2½	3	2½	
12	1	4	3½*	4*	3½*	

Maxam Ltd.

Single-acting cylinders arranged to push are non-cushioned, and available with a ⅞-in. bore and strokes of ½, 1 and 1½ in. in mounting styles A, C. D and G. Double-acting non-cushioned cylinders of ⅞-in. bore are also available with strokes to order.

Maxam Mk. 2 3-in.-dia. cylinder, suitable for pneumatic or low pressure hydraulic systems.

Bore (in.)	Standard strokes (in.)	Standard port (B.S.P.)	Piston rod end B.S.F. external	Standard mounting
Double-acting (non-cushioned or with adjustable cushioning)				
1½	To order	¼	⅜	A, C, D, G, J, F
2½		¼	⅜	A, C, D, G, J, F
3		¼	⅜	C, D, E, G, F, J, and direct mounting
4		¼	1	
5		¼	1¼	
6		¼	1½	
8		¼	2 Ext. Whit.	C, D, E, G
10		¼	2	
12		¼	2	

Oddy Engineering Ltd.

(A) indicates drill sizes in plain rod dia., as shown in the table. Maximum working pressure is 2,000 p.s.i. (oil). Other cylinders are available to 12 in. dia. and 12 in. stroke at pressures up to 8,000 p.s.i.

Single-acting cylinders (arranged to push), single-acting cylinders (arranged to pull) and double-acting cylinders

Bore (in.)	Standard stroke (in.)	Standard port (B.S.P.)	Piston rod ends			Standard mounting
			Plain dia. (in.)	(A) (in.)	Threaded B.S.F. ext.	
1½ 1¾ 2 2⅜ 2¾ 3 3½ 4	To order	⅜ ⅜ ½ ½ ½ ½ ½ ½	⅞ 1 1⅛ 1¼ 1⅜ 1½ 2 2	½ ½ ½ ½ ½ ½ 1 1	⅞ 1 1⅛ 1¼ 1⅜ 1½ 1¾ 1¾	G

Oil-Dyne Inc.

(distributed by British Arca Regulators Ltd.)

All cylinders are available with external or internal threads on the piston-rod ends, for which various end fittings are obtainable. Maximum working pressure is 5,000 p.s.i.

Telescopic cylinders are available to special order, as single- or double-acting cylinders in two, three or four sections.

Dry rod cylinders are also available to special order, in bores as above, but are not available in telescoping cylinders. They are not recommended for use with foot mountings or front plate end mountings.

Note: Double-ended piston rod models are not available in mounting style G.

Double acting cylinders (non-cushioned) in single- and double-ended piston rod styles.

Bore (in.)	Stroke (in.)	Standard port	Piston rod dia. (in.)		Standard mounting
			Standard	2/1 Type	
½ ¾ 1 1¼ 1½ 2 2½ 3 4	To order	Male ports of various sizes and ports for "O" ring type fitting. Female ports of various sizes.	0·25 0·375 0·437 0·562 0·625 0·875 1·062 1·437 2·125	— 0·50 0·687 0·875 1·062 1·438 1·750 2·125 2·875	C, D, G, J and (A)

(A) indicates plain end mounting (tapped holes in end faces).

Pratt Precision Hydraulics Ltd.

For all units, the cylinder head is rotatable for convenient positioning of the port. Jacks are available cushioned at either or both ends of stroke (fixed or adjustable cushioning), or can be supplied with no cushioning. Air bleed screws are provided, and double-rod cylinders are available, with alternative piston seals.

Single- or double-acting cylinders. Maximum working pressure 750 p.s.i.

Bore (in.)	Stroke	Standard port (B.S.P.)	Piston rod end		Standard mounting
			dia.	B.S.F. external	
1½ 2 3 4	To order	¼ ⅜ ½ ¾	⅝ ⅞ 1 1⅜	⅜ ½ ⅝ 1	C, D, G and J

Single- or double-acting cylinders. Maximum working pressure 2,000 p.s.i.

Bore (in.)	Stroke	Standard port (B.S.P.)	Piston rod end			Standard mounting
			dia.	B.S.F. external	B.S.F. internal	
1½ 2 3 4 5 6	To order	¼ ⅜ ½ ¾ 1 1½	⅝ 1 1⅜ 1½ 2 2 2¼ 2½ 3⅛ 3 4¼	⅝ 1 1⅜ 1½ 1½ 1½ 2 2⅛ 2½ 2½ 3½	9/16 11/16 1 1⅜ 1⅜ 1⅜ 1⅝ 1⅝ 1⅞ 2⅛ 2⅝	C, D, E, F, G, J, M, P

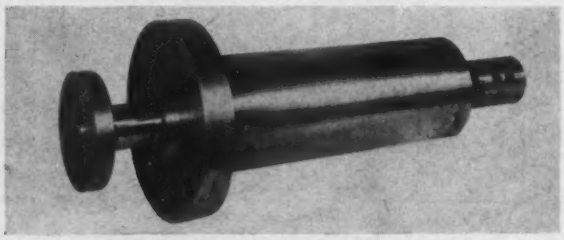
Power Jacks Ltd.

Cylinders for normal working pressures of 1,500 p.s.i. Maximum pressure of 3,000 p.s.i.

Cylinder dia. (in.)	Standard stroke (in.)	Standard port (B.S.P.)	Piston rod end		Standard mounting
			Plain dia. (in.)	Hole dia. (in.)	
Single acting, to push					
1·125	1–12 and 12·5–24 in ½-in. increments	⅛	⅞	½	G
1·417	2–18 and 19–30	⅛	1·12	0·64	
1·786	2–18 and 19–30	⅛	1·12	0·64	
2·125	2–24 and 25–36	⅛	1·62	0·76	
2·75	2–24 and 25–42	⅛	2·0	1·14	
3·0	3–42	¼	1·65	1·0 B.S.F. (F)	
3·75	3–48	¼	2·06	1¼ B.S.F. (F)	
4·625	3–48	¼	2·37	1½ B.S.F. (F)	
Single acting, to pull					
1·417	2–42	⅛	0·81	$\frac{7}{16}$ B.S.F. (F)	
1·786	2–42	⅛	1·09	⅝ B.S.F. (F)	
2·125	2–48	⅛	1·15	¾ B.S.F. (F)	
2·75	2–48	⅛	1·75	1·0 B.S.F. (F)	
3·0	3–42	¼	1·65	1·0 B.S.F. (F)	
3·75	3–48	¼	2·06	1¼ B.S.F. (F)	
4·625	3–48	¼	2·37	1½ B.S.F. (F)	
Double acting					
1·417	2–18	⅛	0·81	$\frac{7}{16}$ B.S.F. (F)	
1·786	2–18	⅛	1·09	⅝ B.S.F. (F)	
2·125	2–24	⅛	1·15	¾ B.S.F. (F)	
2·75	2–24	⅛	1·75	1·0 B.S.F. (F)	
3·0	3–42	¼	1·65	1·0 B.S.F. (F)	
3·75	3–48	¼	2·06	1¼ B.S.F. (F)	
4·625	3–48	¼	2·37	1½ B.S.F. (F)	

Rhodes, Gill & Co. Ltd.

All cylinders are available in single-acting, double-acting or constant pressure types, with cushioning front, rear or both ends. All units may be obtained either in the high-pressure range (maximum oil pressure 4,480 p.s.i.) or in the low-pressure range (maximum oil pressure 2,240 p.s.i.). Cylinders are also designed and made for specific pressures. Cylinders for oil or water use are available, and special units are made to order.



Flange-mounted cylinder, by Rhodes, Gill & Co. Ltd.

Bore (in.)	Standard stroke (in.)	Piston rod end	Standard mounting
2 3 4 5 6 7 8	To order	Ten standard types of end fitting available for all cylinders.	C, D, E, F, G, H, J, K, M, and O

Rivett Lathe & Grinder Inc.

(*distributed by British Arca Regulators Ltd.*)

The 2/1 oversize piston rod models each have a piston rod, the area of which is one-half the area of the cylinder. This larger rod, reducing oil displacement by approximately one-half, enables the rod to travel in one direction at a speed double that in the opposite direction. This feature can be employed in an open circuit to retract the piston at twice the speed it extends, thus shortening cycle time and speeding up work. It is also an advantage when extra stiffness is required. All strokes are to order.

Maximum working pressure of the ordinary cylinders is 1,500 p.s.i. Other cylinders are available for pressures as low as 300 p.s.i., or in excess of 3,000 p.s.i.

*Double-acting cylinders (non-cushioned or cushioned at either or both ends of stroke). Single- and double-rod models.**

Bore (in.)	Piston rod dia.		Standard mounting
	Standard dia. (in.)	2/1 Type (in.)	
2	1·0	1⅜	C, D, F, G, J, P† and Rabbet‡
2½	1·0	1½	
3	1⅜	2⅛	
3½	1⅜	2⅛	
4	1⅜	2⅛	
5	1⅜	3⅛	
6	2⅛	4½	
7	2⅛	5	
8	2⅛	5¾	
10	2⅛	7	

* *Double rod models are not available in mounting styles D and G.*
† *The Piston rod diameters quoted for the 10-in.-dia. cylinder are not applicable to mounting style P.*
‡ *2/1 piston rod model is not available in Rabbet mounting style.*

Short Brothers & Harland Ltd.

A special spring return jack with a piston diameter of 2·75 in. is available with a stroke of 1·25 in., and a hydraulic start ram of 2 in. dia. and 1 in. stroke is also available.

Single-acting cylinders designed primarily for applying tensile loads during structural testing

Bore (in.)	Standard stroke (in.)	Standard port (B.S.P.)	Piston rod end external Whitworth form (dia. × t.p.i.)	Standard mounting
3·55	18·0	¼	1·70 in. × 20	G
4·5	12·0		1·70 in. × 20	
5·6	30·0		1·70 in. × 20	
8·75	12·0 and 18·0		3·4 in. × 16	
11·00	12·0		4·1 in. × 16	
16·00	36·0		5·0 in. × 16	

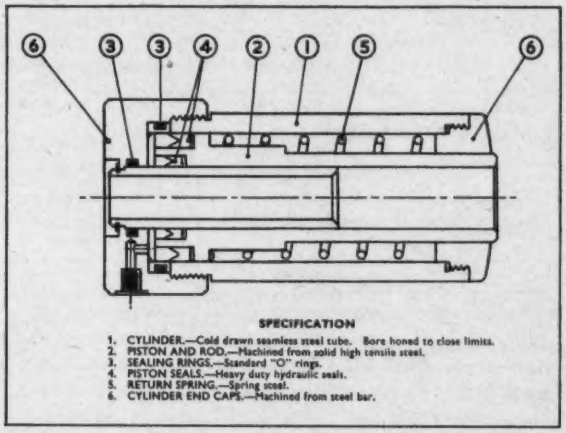
Double-acting jack for a marine hydraulic system (Short Brothers & Harland Ltd.).

Double-acting cylinders

Bore (in.)	Standard stroke (in.)	Standard port (B.S.P.)	Piston rod dia.	Standard mounting
2·5	10·0	¼	1·5*	G
2·5	13·0		1·5*	
3·75	10·0		2·0*	
3·75	12·0		2·0*	
3·75	14·5		2·0*	

Staffa Ltd.

Type BB cylinders are for pressures up to 2,000 p.s.i., thrusts up to 40 tons and strokes up to 10 ft. Type C cylinders are for pressures up to 6,000 p.s.i., thrusts up to 100 tons and strokes up to 36 in. All types of mounting may be obtained to order and various piston rod end styles are available.



SPECIFICATION

1. CYLINDER.—Cold drawn seamless steel tube. Bore honed to close limits.
2. PISTON AND ROD.—Machined from solid high tensile steel.
3. SEALING RINGS.—Standard "O" rings.
4. PISTON SEALS.—Heavy duty hydraulic seals.
5. RETURN SPRING.—Spring steel.
6. CYLINDER END CAPS.—Machined from steel bar.

Staffa hollow piston rod single-acting jack.

Single-acting (arranged to push, spring return)—hollow piston rod

Bore (in.)	Standard stroke (in.)	Standard port (B.S.P.)	Piston rod end dia (in.)		Nominal thrust at 5,000 p.s.i. tons
			Outside	Inside	
2⅜	3	¼	1 3/16	⅜	7
3⅜	4	¼	2⅛	1⅛	15
4½	5	¼	2⅞	1⅜	25
5⅜	6	⅜	3½	1⅝	40
6½	6	⅜	4½	2½	60
7½	6	⅜	5	2½	80

Single-acting—arranged to push, spring return

Bore (in.)	Standard stroke (in.)	Standard port (B.S.P.)	Piston rod end plain dia. (in.)	Overall cylinder length closed (in.)
1¾	1	¼	1	4⅜
2⅜	1	¼	1⅛	4½
3⅜	1	¼	2⅛	5⅞
4½	1	¼	2⅞	6⅜
5⅜	1	¼	3⅜	7⅜
6½	1	¼	4½	8
7½	1	¼	5½	8⅜

These units are for pressures up to 6,000 p.s.i., exerting thrusts up to 100 tons, with 1-in. stroke, and are suitable for jacking heavy loads in confined spaces.

Single- and double-acting cylinders (types BB and C)

Bore (in.)	Standard stroke (in.)	Standard port (B.S.P.)		Piston rod dia. (in.)		Standard mounting
		Type BB cylinder	Type C cylinder	Type BB	Type C	
1¾	To order	¼	⅜	1⅛	1½	Plain, C, D, G and E
2⅜		¼	⅜	1⅜	1½	
3⅜		¼	⅜	2½	2⅞	
4½		¼	⅜	3	3½	
5⅜		¼	⅜	3½	4⅜	
6½		¼	⅜	4½	5⅜	
7½		¼	⅜	5	6½	

Stein Atkinson Vickers Hydraulics Ltd.

Oil hydraulic cylinders are available in a standard stock range in sizes from 2 to 6 in. bore, and strokes up to 7 ft. 0 in. at 1,500 p.s.i. maximum. Adjustable cushioning can be provided at either or both ends of stroke, and foot, flange or eye mountings are available. The standard range will satisfy the majority of applications, but special cylinders

Typical hydraulic cylinder, by Stein Atkinson Vickers Hydraulics Ltd.

can be manufactured up to 6 in. bore and 9 ft. 0 in. stroke for working pressures up to 2,000 p.s.i. Hydraulic boosters incorporating a control valve, designed for power-assisted steering, can also be used as linear actuators in certain industrial applications.

Bore (in.)	Stroke min. (in.)	Stroke max. (in.)	Standard port (taper B.S.P.)	Piston rod end Plain dia. (in.)	Piston rod end Threaded (B.S.F.)	Standard mounting
2·0	1¾	36	¼	1·0	⅜	C, J
2·5	1⅞	50	¼	1¼	⅜	
3·0	1¼	60	¼	1½	1⅛	
4·0	1⅜	68	¼	2·0	1½	
5·0	1¾	84	1·0	2½	1¾	
6·0	2⅛	84	1·0	2½	1¾	

Bore (in.)	Stroke min. (in.)	Stroke max. (in.)	Standard port (taper B.S.P.)	Piston rod end Plain dia. (in.)	Piston rod end Threaded (B.S.F.)	Standard mounting
2·0	1¾	15	¼	1·0	⅜	D
2·5	1⅞	20	¼	1¼	⅜	
3·0	1¼	27	¼	1½	1⅛	
4·0	1⅜	30	¼	2·0	1½	
5·0	1½	34	1·0	2½	1¾	
6·0	2⅛	34	1·0	2½	1¾	
2·0	1¾	9	¼	1·0	⅜	G
2·5	1⅞	12	¼	1¼	⅜	
3·0	1¼	17	¼	1½	1⅛	
4·0	1⅜	18	¼	2	1½	
5·0	1¾	20	1·0	2½	1¾	
6·0	2⅛	20	1·0	2½	1¾	

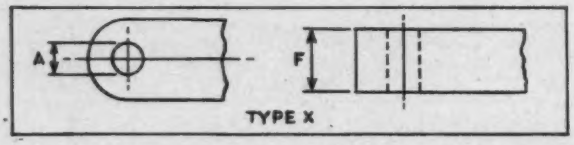
Spenborough Engineering Co. Ltd.

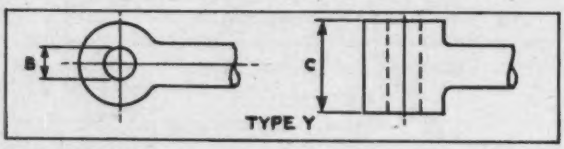
Single-acting cylinders, to push (single extension type)

Bore (in.)	Stroke (in.)	Piston rod end type X Dim. A (in.)	Piston rod end type X Dim. F (in.)	Capacity (tons)	Standard mounting
1½	to order	½	⅞	0·888	G
1¾		⅝	1⅛	2·1	
2⅛		1	2½	3·9	
3		1	2½	6·2	
3¾		1⅛	3⅛	9·8	
4⅛		1½	4¼	14·9	
5		1¾	3	17·5	
6		2	3½	25·4	
7		2½	3½	34·3	

Single-acting, to push (telescopic—double extension type)

Bore (in.)	Stroke (in.)	Piston rod end type X Dim. A (in.)	Piston rod end type X Dim. F (in.)	Capacity (tons)	Standard mounting
1¾ and 1½	To order	½	⅞	0·888	G
2⅛ and 1¾	,, ,,	⅝	1⅛	2·1	
3 and 2⅛	,, ,,	1	2½	3·9	
3¾ and 3	,, ,,	1	2½	6·2	
4⅛ and 3¾	,, ,,	1¼	3⅛	9·8	
3 and 2⅛	,, ,,	Universal ball mounting		3·9	Universal ball mounting
3¾ and 3	,, ,,			6·2	
4⅛ and 3	,, ,,			9·8	





Types of piston rod ends for cylinders, by Spenborough Engineering Co. Ltd.

Double-acting cylinders (single extension)

Bore (in.)	Stroke (in.)	Piston rod dia. (in.)	Piston rod end type Y Dim. B (in.)	Piston rod end type Y Dim. C (in.)	Capacity (tons) Push	Capacity (tons) Pull	Standard mounting
1½	To order	⅝	¾	1¼	0·888	0·613	G
1⅞		⅝	¾	1⅛	0·888	0·492	
1¼		⅝	¾	1⅛	0·888	0·350	
1½		1	1	1½	2·1	1·44	
1¾		1	1	1½	2·1	1·26	
1½		1	1	1½	2·1	1·05	
2⅛		1	1¼	1½	3·9	3·25	
2⅛		1⅛	1⅛	1½	3·9	3·10	
2⅛		1¼	1⅛	1½	3·9	2·86	
2⅛		1⅜	1⅛	1½	3·9	2·63	
2⅛		1½	1⅛	1½	3·9	2·38	
3		1⅛	1⅛	2·0	6·29	5·43	
3		1¼	1⅛	2·0	6·29	5·22	
3		1⅜	1⅛	2·0	6·29	4·99	
3		1½	1⅛	2·0	6·29	4·74	
3		1⅝	1⅛	2·0	6·29	4·46	
3¾		1⅜	1½	2½	9·8	7·5	
3¾		1½	1½	2½	9·8	7·25	
3¾		1⅝	1½	2½	9·8	7·0	
3¾		1¾	1½	2½	9·8	6·75	
4⅛		1⅞	1½	2½	13·0	11·0	
4⅛		2	1½	2½	13·0	10·75	
4⅛		2¼	1½	2½	13·0	10·50	
4⅛		2¼	1½	2½	13·0	10·25	
5		2½	1¾	3	17·5	13·2	
6		3	2	3½	25·4	19·0	
7		3	2½	3½	34·3	28·0	

All cylinders' capacities are quoted for a maximum working pressure of 2,000 p.s.i.

The United States Metallic Packing Co.

Maximum working pressure is 1,500 p.s.i. Cylinders are available either non-cushioned, or with adjustable cushioning at either or both ends.

Double-acting cylinders

Bore (in.)	Standard stroke (in.)	Standard port (B.S.P.)	Piston rod end (B.S.F.) Internal	Piston rod end (B.S.F.) External	Standard mounting
1½	To order	¼	¼	¾	J, G, F
2		¼	¼	1	
2½		¼	¼	1¼	
3		¼	1	1¼	
3½		¼	1¼	1¼	
4		¼	1¼	2	
4½		1	1½	2½	
5		1	2	2½	
6		1	2½	3	
7		1½	2½	3½	
8		1½	2½	4	

Weatherley Oilgear Ltd.

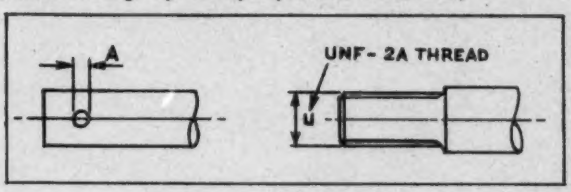
Hydraulic cylinders are normally supplied as part of complete hydraulic systems. All cylinders are available with single piston rods or double-ended piston rods, and adjustable cushioning may be provided for either or both ends. Combinations of standard mountings are available, and special cylinders are made to order.

Double-acting cylinders

Bore (in.)	Standard stroke (in.)	Piston rod dia. (in.) Standard cylinders	Piston rod dia. (in.) Heavy-duty cylinders	Mounting styles
2	To order	1 1¼	1 1¼	Standard cylinders C, D, G, J, P, Heavy-duty cylinders C, D, E, G, J, P, F
2½		1 1½	1½ 1½	
3½		1½ 2½	1⅝ 2½	
4		1½ 2½	2 2½	
5		2 3½	2½ 3½	
6		2½ 4½	3 4½	
7			3½ 5	
8			4 5½	

Weston Works (Birmingham) Ltd.

Strokes are to order in ½-in. increments to 10 in., and 1-in. increments above 10 in. Two piston rod diameters are available on all double-acting cylinders, except 1¼-in. bore. Single-acting cylinders use the larger diameter only. Maximum working pressure is 2,000 p.s.i. Cushioning at ends of stroke, and spring return for single-acting cylinders, may be obtained. (This company's units are based on an original standard range by Dowty Hydraulic Units Ltd.)



End fittings for Weston cylinders.

Single-acting (to push) and double-acting cylinders—non-cushioned

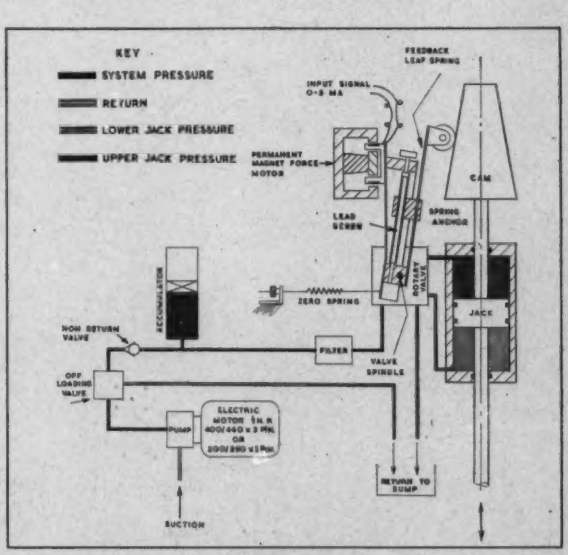
Bore (in.)	Standard port (B.S.P.)	Piston rod end A	Piston rod end U	Piston rod dia. (in.)	Standard mounting
1¼	⅛	0·562	—	⅝	G
1½	⅛	0·875	—	¾ 1	
1¾	⅛	0·875	—	¾ 1¼	
2	¼ or ⅛	1·0	—	1 1¼	
2½	¼ or ⅛	1·125	1¼ × 12	1¼ 1¼	
2¾	¼ or ⅛	1·125	1¼ × 12	1¼ 1½	
3	¼ or ⅛	1·25	1½ × 12	1½ 2	
3½	¼ or ⅛	1·5	1½ × 12	1½ 2½	
4	¼ or ⅛	1·75	1⅞ × 12	2 2½	
4½	¼ or ⅛	2·0	1⅞ × 12	2½ 3½	
5	¼ or 1	2·25	2½ × 12	2½ 3½	
6	¼ or 1	2·75	2⅞ × 12	3 4½	

Wilmot Breeden Ltd.

This unit has been designed specifically as a valve operator for electrically signalled process systems, although other fields of application are being investigated. The actuator is completely self-contained, and requires only suitable electrical power supplies to the electric motor and transmission lines for the d.c. control signal.

The system consists of a power pack having a small electric motor driving a hydraulic pump, together with the necessary pressure control valves, the main body of the unit being the reservoir for the hydraulic fluid. The supply of fluid to the hydraulic jack is controlled by a rotary servo valve operated by a moving coil electro-magnetic force motor. The jack position is made proportional to the input signal by incorporating a spring feedback mechanism which, when the jack has reached the desired position, balances the force generated in the moving coil of the force motor, thus maintaining the servo valve in its neutral position. If the input signal is increased or decreased, the valve is opened, thus initiating jack movement in the required direction, and causing an increase or decrease in the load on the spring tending to close the valve again. When the jack reaches the desired position, the forces balance and the valve is again in its neutral position. In order to vary the jack movement between ½ and 2½ in. and still use the full input signal range for all strokes, the length, and therefore the rate, of the leaf spring can be altered by simply rotating a lead screw incorporated in the feedback assembly, thus moving the spring anchor point. Hence, for a short stroke, a short spring length (i.e. high rate) is required, and vice versa.

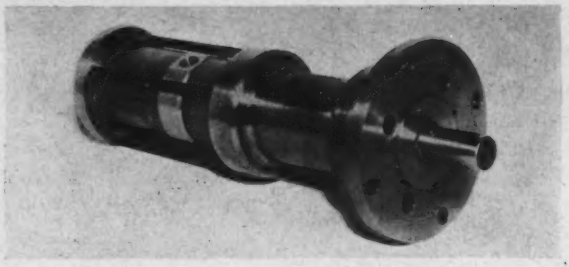
For simple proportional control the cam fitted to the jack is linear, but if it is necessary to "characterise" the movement then a cam of suitable profile can be fitted. The unit can accept all common control signals (e.g. 0-5, 0-15, 3-20 and 10-50 mA).



Principles of the Wilmot Breeden electro-hydraulic actuator.

Advanced Hydraulics Ltd.

This unit is of hydro-mechanical design permitting rotational ranges greater than 360°, this being accomplished by the conversion of a short double reciprocating motion to rotary motion by means of a recirculating ball thread. Units are available with a torque of 180 lb. in. at 1,000 p.s.i. over a range in excess of 720°. Mounting is by a front flange, foot mountings being available to special order.



AHL torque actuator by Advanced Hydraulics Ltd.

Brown Brothers & Co. Ltd.

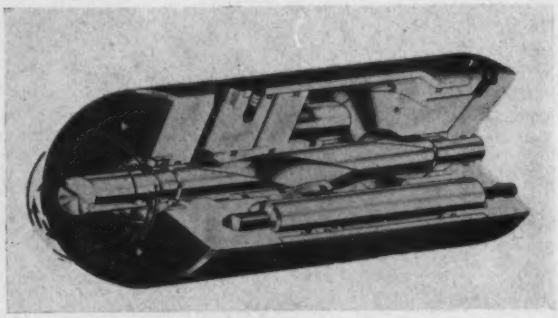
The electro-hydraulic rotary vane equipment made by this company is designed specifically for marine steering gears. The normal angular movement of the rudder stock is 70°, using three moving vanes and three fixed vanes in the casing. A movement of 140° is possible by using two moving vanes and two fixed vanes in the casing. Each vane gear and its ancillary equipment is designed for its own particular installation.

Carter Controls Inc.

(*distributed by British Arca Regulators Ltd.*)

This torque actuator (see illustration) incorporates full cushioning, and provides 0-370° of high torque rotation. Torque output ranges from near zero to 15,000 lb. in., depending on the bore of the unit and the input pressure. These actuators can be powered by oil, air, gas or water, and bore sizes of 4, 5, 6, 8, 10 and 12 in. are available.

For applications where it may be required to operate the actuator independent of an outside power supply, models are available with built-in valving, pumps, motor and make-up reservoir. They are also available with built-in remote poppet or solenoid valves. Mountings include foot, and front or rear flanges.



Torque actuator by Carter Controls Inc.

Dowty Hydraulic Units Ltd.

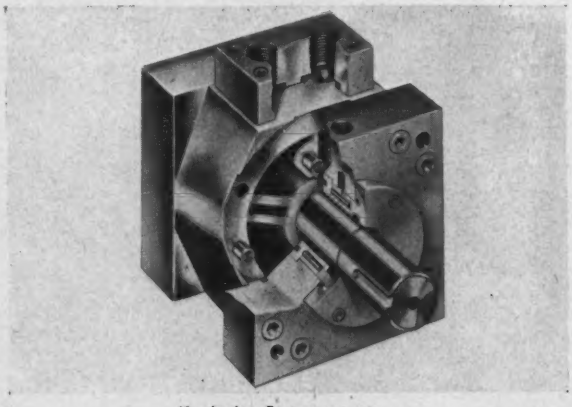
This company design and manufacture hydraulic rotary units for special purposes (this type of unit is incorporated in the digger and power shovel shown on the front cover of *E.M. & D.* for March 1961). Linear jacks are also included in the range of special-purpose hydraulic units available.

Keelavite Hydraulics Ltd.

The type RN Rotac actuator is fitted with precision roller bearings, and is suitable for high pressures and fast cycles. Single vane models are available in five sizes, with torque ratings varying from 100 lb. in. at 100 p.s.i. to 40,000 lb. in. at 1,000 p.s.i. Maximum rotation is 280°, the displacement varying between 9·2 and 253·3 cu. in. according to the size. For double vane models, a similar range of sizes is available, with torque ratings from 240 lb. in. at 100 p.s.i. to 92,000 lb. in. at 1,000 p.s.i. Displacement for maximum rotation of 100° ranges from 6·6 to 181 cu. in. All Rotac actuators are available with foot, flange or base mounting, and shafts which may extend from either or both ends of actuator body are keyed. Double vane actuators are pressure balanced.

The type HN Rotac actuator is manufactured in the U.S.A., and can be obtained to special order. It is a plain bronze bearing unit suitable for operation at moderate pressures and cycles, and is available in eight sizes with single or double vanes.

This company also produces a hydraulic actuator in the form of a steering unit, primarily designed for use on small marine vessels, consisting fundamentally of a hydraulic cylinder with an integral control valve.



Keelavite Rotac actuator.

Lockheed Precision Products Ltd.

Cylinders are available with a shaft at either end or both ends. Maximum permissible working pressure is 1,000 p.s.i.

Semi-rotary slave. Single-vane type (300° rotation); double vane (120° rotation)

Type no.	Torque (lb. in.)		Standard port (B.S.P.)	Shaft ends, Class 1 fit to BS 2059		Standard mounting
	Single vane	Double vane		Dia. (in.)	No. of serrations	
32	1,270	2,840	¾	1¼	24	C, D, J
34	2,540	5,680	¾	1¼	24	
43	4,300	9,700	¾	1¼	24	
46	8,600	19,400	¾	1¼	24	
64	11,000	24,300	1	2¼	36	
68	22,000	48,600	1	2¼	36	
85	32,500	73,000	1	3	40	
811	65,000	146,000	1	3	40	
138	113,000	253,000	These units to order only			
1312	170,000	379,000				
1812	333,000	730,000				
1818	500,000	1,100,000				

Staffa (Chamberlain Industries Ltd.)

Rotary actuators

Size (in.)	Internal dia. of cylinder (in.)	Effective length of cylinder (in.)	Maximum working pressure (p.s.i.)	Theoretical torque (lb. in.)
6 × 4	6	4	1,000	11,000
10 × 12	10	12	1,000	125,000

Rotational travel approximately 220°.

B. & P. Swift Ltd.

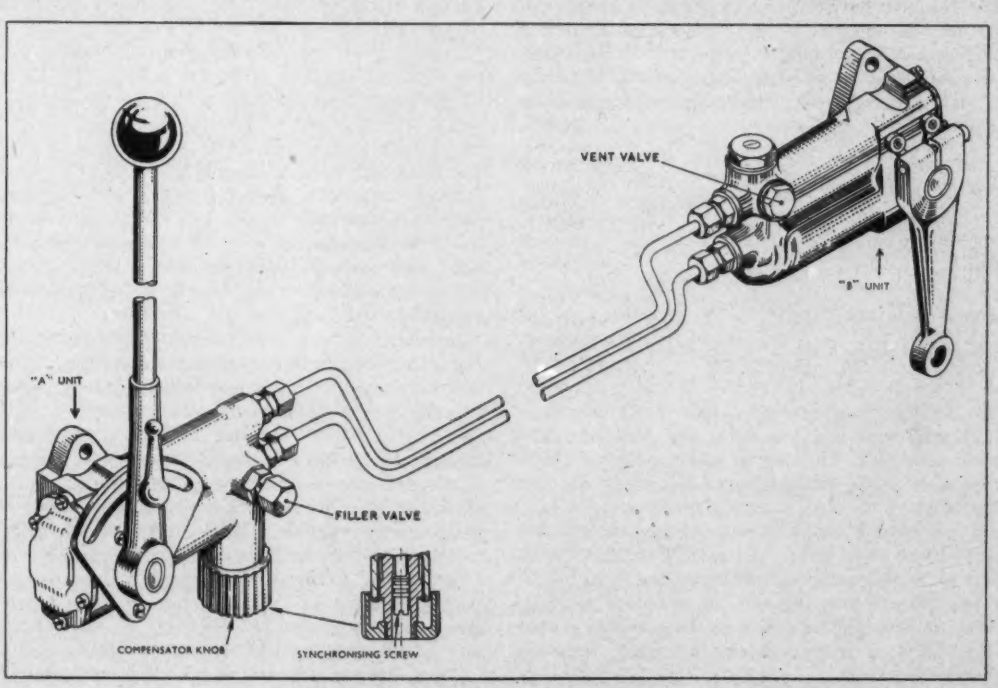
The rotary torque actuator developed by this company has a maximum rotation of 330°, and is capable of producing a torque rating of 100,000 lb. in. at 2,000 p.s.i. fluid pressure. Attachment points are built in on the actuator body, the ports being tapped ¼ B.S.P.

REMOTE CONTROL ACTUATOR

Armstrong Patents Co. Ltd.

This actuator is a remote control unit, consisting of an A and B unit connected by a pair of pipes, movement of the A unit lever being repeated by the B unit lever. Hydraulic slackness or stiffness of installation, due to fluid contraction or expansion brought about by temperature changes, is readily adjustable by means of a temperature compensation knob. Provision is made for synchronising the movements of levers on the A and B units.

A wide variety of accessories is available, including hand levers with quadrants and provision for a locking lever in any position, lever arms for B units, face plates, stub levers and shaft extensions. The A and B units are available in a range of piston sizes, and circuits can be arranged using multiple B units with one A unit, or vice versa. Linear actuators are available, and also hand and power pumps.



Remote control actuator by Armstrong Patents Co. Ltd.

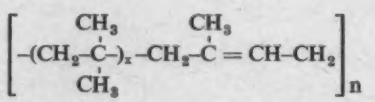
A length of giant-sized butyl tubing being extruded.

BUTYL RUBBER

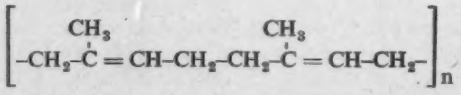
Esso Petroleum Co. have announced plans for a £4,300,000 plant, at Fawley, which will have an annual production of 30,000 tons of butyl rubber. This will be the world's fifth, and the U.K.'s first, butyl plant

by T. H. H. SKEET, LL.B., M.P.

BUTYL is a product of oil formed by reacting two refinery gases, isobutylene and isoprene, at about −90 deg. C. As will be apparent from a close examination of Table 1, it possesses many unique properties not associated with either natural rubber or SBR. These are due in part to its closely packed molecular structure and low degree of unsaturation:



butyl rubber



natural rubber

Though a soft thermoplastic copolymer prior to vulcanisation, heat treatment will transform the material into a tough elastic substance. The degree of elasticity or toughness may be modified by the addition of suitable fillers, such as carbon black and chalk, during processing. Unlike natural and neoprene rubbers, which can be vulcanised at room temperature by using vulcanising agents, butyl responds to such treatment with difficulty due to its chemical inertness. Though this presents an apparent disability in processing, it nevertheless enhances the ultimate properties, making butyl at once resistant to ageing, heat and chemical attack.

Prior to 1954, butyl was chiefly used for the manufacture of inner tubes. Due to technological change and the introduction of the tubeless tyre demand fell somewhat, but in recent years its market has been substantially broadened.

During 1959, the Atlas Bucron tyre was introduced into the U.S. market with promising results. It is recorded that on wet roads a vehicle fitted with these tyres travelling at 60 m.p.h. will stop in 170 ft. when the wheels are locked. The comparable result with SBR is something in the order of 240 ft. On dry roads a butyl tyre travelling at 40 m.p.h. will stop in 40 ft—for SBR the figure is 70 ft. Further, the modern motor car in the U.S.A. contains some seventy butyl components, ranging from window strips to radiator hose, and sealing gaskets to rubber mounts, reflecting its ability to withstand heat and prolonged exposure to the elements.

Standard Oil Co. (New Jersey) recorded a 35 per cent expansion in sales in 1959, and indicated that further manufacturing capacity is being installed. A plant at Port Jerome commenced production in 1959.

An additional factor that is likely to commend butyl to designers is its low cost and relative stability in price. Butyl is cheaper than either natural, SBR, most grades of neoprene, or Thiokol. Raw butyl is marketed at 1s. 9½d. a lb. It should be appreciated, however, that the differential is to some extent diminished by processing costs.

Butyl has certain limitations, which are shared by the natural product in that it is neither oil nor fire resistant, but frequently these disabilities are insufficient to outweigh its positive advantages in many applications.

Brief reference to butyl in several recent applications may prove profitable. A steady outlet for the polymer has been

developed in conveyor belting for the transference of hot and/or cold abrasive materials. Moreover, the system reveals good flex resistance and ageing properties. Thus, at the I.C.I. plant at Billingham, butyl belts are used to convey granular fertiliser at certain stages during processing, at a temperature of 110 deg. C., up a substantial gradient at a rate of 220 ft./min. Conventional materials lasted about a year. The butyl belting which replaced them has been in continuous service for three years without serious impairment of strength and reliability. Significant savings in cost have been achieved. The belting is normally reinforced with cotton fabric, but this to some extent limits the temperature of the load that may be carried. The use of terylene will certainly obviate this difficulty, but further research will have to be undertaken to find a suitable method of bonding these two synthetic materials.

The prospect of using butyl in the building and construction industries is most encouraging. Thus, the development of effective bonding between butyl and glass has marked out the product as particularly serviceable for window seals. Further, its adhesion to a variety of constructional materials, and resistance to stains and shrinkage, have singled it out as a useful seal for building components. Miscellaneous uses include the installation of heavy machinery on butyl mounts to eliminate vibration and noise, the lining of metal tanks to carry liquids over a wide range of temperatures from 0 deg. C. to about 105 deg. C., and incorporation in paints.

Since butyl may be readily dissolved in both aromatic and aliphatic solvents, it appears to have many of the characteristics acquired for a rubberised paint, and a number of manufacturers have demonstrated that the properties outlined can in fact be realised in a paint film. Unvulcanised butyl may be used for a one-part paint in conjunction with pigments and resin. Experiments have indicated that the paint may be applied without difficulty to structural steelwork, and that there is no tendency for the first coat to lift following the application of the second. After a year's weathering in coastal atmospheric conditions, the condition of the product was most satisfactory.

Butyl rubber as produced requires no breakdown to obtain a solution. The Mooney viscosity, which is related to the molecular weight, is lowest in grades 035, 150, 215 and 325, whilst grades 217 and 218 have appreciably higher Mooney viscosities. The mole per cent unsaturation increases from 0·6 for 035 to a maximum of 2·5 in grade 325. Grades designated 165, 268 and 365 differ from grades 150, 218 and 325 in that they incorporate a non-staining stabiliser in place of the phenyl beta naphthylamine which is used in regular grades.

It should be recognised that increased unsaturation tends to decrease ozone and acid resistance on the one hand, and to increase heat and solvent resistance on the other. These factors must be borne in mind in the selection of the grade required for the particular application. These additional points may prove helpful on this topic:

Fillers: For cohesivity and tack—zinc oxide, aluminium hydrate, whiting and thermal blacks.
For strength and toughness—silica, silicates and fine particle blacks.
For impermeability to gases and acids—mica, graphite or talc.
For encouraging stiffness—magnesium oxide and carbonate.
For increased body—employ PIB grades having molecular weight ranges from two to four times that of butyl rubber.

Additives: For non-vulcanising systems, a wide range of resins and polymeric additives are employed, including modified phenolics, Stabylite ester gum, etc. Processing oils are not generally used in butyl rubber compositions, since there is no need to soften the rubber, and their presence affects the ageing characteristics.

Solvents: Butyl rubber is readily soluble in aromatic and aliphatic solvents, the choice depending upon the viscosity characteristics required for brushing and subsequent evaporation rates. The solvents recommended are Esso Commercial Heptane 63 to 73 deg. C., Esso Solvent 50-90 to 105 deg. C., and Esso Solvent 40-100 to 120 deg. C. Benzene, toluene and xylene are also excellent.

Butyl, having a tightly packed structure, releases solvent from solutions rather slowly; this can lead to porosity. For this reason, churning processes which tend to trap air should be avoided, but should entrapment occur a warming operation is advisable.

It is thought that the negligible water absorption of the polymer prevents deterioration of the bond by rust formation on the interface, thereby eliminating the need for a primer coating.

Butyl in latex form may be used for coating paper, textile finishing, paint emulsion and a number of other applications.

Table 1. Chemical resistance of butyl, natural and nitrile rubbers

	Polymer		
Fluid	*Butyl*	*Natural*	*Nitrile*
Acetone	E	E	P
Acids	E	E	G
Alcohols, ethyl	E	E	E
isopropyl	E	E	E
amyl	E	E	E
benzyl	E	E	E
Alkalis	E	E	G
Analine	E	P	P
Animal fats and oils	E	P	G
Benzene	P	P	G
Butyl acetate	E	P	G
Butane	P	P	E
Carbon disulphide	P	P	G
Carbon tetrachloride	P	P	P
Chloroform	P	P	P
Cottonseed oil	E	P	E
M-cresol	E	E	E
Dibutyl phthalate	G	G	P
Diethylene glycol	E	E	E
Dioctyl phthalate	G	G	P
Ethyl acetate	E	G	G
Ferric chloride	E	P	P
Furfural	E	E	G
Gasoline	P	P	E
Glycerine	E	E	E
N-heptane	P	P	E
Hexane	P	P	E
Kerosene	P	P	E
Linseed oil	E	P	E
Mineral oil	P	P	E
Naphtha petroleum	P	P	E
Nitrobenzene	E	G	P
Iso-octane	P	P	E
Ozone	E	P	P
Phenol	E	E	G
Phosphoric acid	E	P	P
Propane	P	P	E
Skydrol	E	P	P
Skydrol 500	E	P	P
Toluene	P	P	E
Tri-cresyl-phosphate	E	P	P
Turpentine	P	P	E
Vegetable oils	E	P	G
Xylene	P	P	E

E—Excellent for service in this fluid.
G—Fair to good for service in this fluid.
P—Poor for service in this fluid.

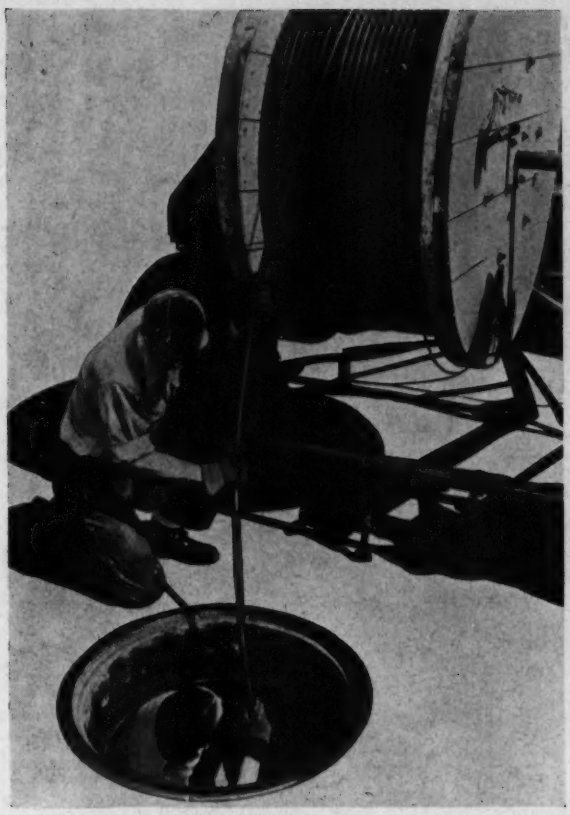
Table 2. Properties of butyl

Property	Basis of Property	Applications
Shock Absorption	Due to lack of resilience, mechanical shock is absorbed rather than dissipated through reflex action. The design engineer may use a chemical promoter to modify and control resilience.	Load cushions replacing the leaf spring in tandem axles for large vehicles; body bumpers and engine mounts; drive shaft insulators and bushes. Tyres for more comfortable riding.
Sound Absorption	Due to the absorption of audio-frequencies.	Variety of sound insulation, and use in reducing the screech of a wheel turning a bend sharply.
Abrasive Resistance	Maximum abrasive resistance is obtained by designing the material to be somewhat soft, while simultaneously maintaining a high strength. Abrasion is thus avoided by the rubber forming around the abrasive particle to which it is exposed.	In vehicles it results in improved traction, braking and skid resistance, particularly on wet roads; avoidance of excessive wear can promote durability. Tyres, pedal pads, accelerator bellows. In conveyor belting it resists granular abrasion, particularly with wet and/or hot loads, viz. aluminium oxide.
Gas Impermeability * Tenfold more effective than conventional rubbers up to at least 205 deg C.	Impermeability to gas and water vapour, due to close molecular structure.	Inner tubes for tyres. Inflatable sports goods. Stoppers for medicine bottles. Packaging seals. Hoses, valves and diaphragms.
Chemical Resistance Resistant to HNO_3, H_2SO_4, etc. Resistance may be enhanced by compounding or curing. Resistant to oxygenated solvents, viz. ketones, esters and alcohols. Fair resistance to certain aromatics and halogenated solvents. Exposure to aliphatic hydrocarbons induces swelling, but may not seriously interfere with its use. Resistant to animal and vegetable oils, but not mineral oils.	Due to the low unsaturation of the butyl molecule.	Tank linings and components of washing machines and dish washers liable to exposure to detergents. Conveyor belting.
Electrical Properties	Butyl is a saturated polymer free from electrolytes. The relatively low dielectric constant and power factor of butyl installation prevents excessive dielectric loss. Thus, it has insulation properties; corona resistance; heat resistance; and negligible water and moisture absorption.	Power cables, busbar and transformer insulation; cables in use withstand up to 22 kV. Operating temperatures of butyl insulated cables are as much as 7 deg C. above those of conventional rubbers. Butyl transformer casings are resistant to moisture penetration in all weathers, and eliminate the need for the conventional metal box. Butyl also provides electrical components with resistance to mechanical shock.
Resistance to Weathering † Ozone resistance — withstands prolonged exposure to sunlight and staining and ageing. ‡	Due to the inert characteristic of polyisobutylene, and low degree of unsaturation.	Rubber materials subject to prolonged storage. Car windows and door seals. Irrigation and commercial tubing. Insulated stator elements and automative parts.
Heat Resistance Butyl compounds will perform satisfactorily under continuous operation in dry heat up to a temperature of 180 deg. C.; at intermittent temperatures as high as 230 deg. C. in both dry air and superheated steam. Dimenthylol phenol will produce a butyl vulcanisate with an even higher heat resistance than conventional curing agents. Through adding neoprene, softening of butyl will be resisted on exposure to extreme temperature.	Due to absence of excess double bonds, the presence of a sufficient number of cross-links, and low gas impermeability.	Steam hose. Radiator hose to resist both heat and chemical attack. Conveyor belting, indefinite use up to 120 deg. C.; suitably compounded, this may be extended to 230 deg. C. Power cables, up to between 85 and 90 deg. C.
Low Temperature Flexibility Such materials will function satisfactorily at temperatures as low as −56 deg. C.	Withstands crystallisation of the rubber structure.	Inner tubes. Aircraft hydraulic system seals liable to exposure to extreme cold.

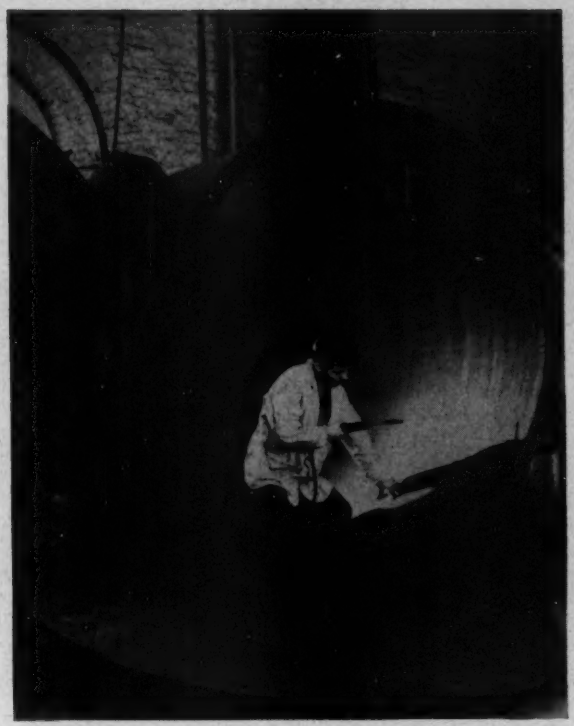
* *Impermeability:* This characteristic arises from the fact that the passage of air through the butyl polymer is very small. Thus, gas permeability at 20 deg. C. is 5 per cent with butyl compared to 15 per cent for neoprene and 100 per cent for natural. At 100 deg. C the figure for butyl is some 17 per cent, compared to natural 100 per cent. This property, invaluable in the finished product, may cause difficulty in processing. Thus, high temperature mixing is essential to ensure that trapped air is excluded prior to vulcanisation.

† *Weather Resistance:* Assuming that maximum weather resistance is desired, satisfactory performance may be achieved by suitably compounding silicone, Chlorosulphonated polyethylene, nitrile and polychloroprene type rubbers, and butyl. The selection of the appropriate material for the work in question will be determined by evaluating the other properties of the polymers under consideration, including their relative cheapness. It is sometimes assumed that the addition of butyl to SBR will improve the weather characteristics, but this is seldom the case. Success may, however, be achieved by the addition of anti-oxidants and wax, instead of brominated butyl.

‡ *Ageing:* Although resistance to ageing may be enhanced by the addition of protective agents to natural or SBR, the relief afforded is not likely to be permanent.



Electrical cable insulated with butyl.



This tank is lined with $\frac{3}{16}$ in. of butyl to withstand the attack of an acid solution of cuprous chloride. A 20,000-V. spark test is shown being applied to ensure continuity of the lining.

Conclusion

Butyl research is moving into a further state of development. Through the modification of the molecular structure by either chlorination or bromination, new products may be devised. In this way a polymer might be prepared to withstand heat up to 205 deg. C., making it particularly valuable for high-temperature conveyor belt systems and for food packaging.

TESTING HONEYCOMB FOR FATIGUE

HONEYCOMB sandwich structural panels as used in modern aircraft are subjected to extremely intense high-frequency vibrations. These occur as a result of the acoustic energy generated by the exhaust of high-thrust turbo-jet engines. As in the case of most materials used in aircraft, it is necessary to have some means of testing their quality before use. Present methods for destructively testing the panels utilise some form of sound generator, which directs its energy at the panel to induce the desired vibrations. The principal disadvantages of this method are: (a) the high noise output of the siren, which requires considerable precautionary measures to protect the operators; (b) the inefficiency produced by the ineffective coupling of the acoustic energy into the panel; and (c) the inability of the siren to duplicate the random variable frequency and amplitude type of noise produced by jet engines.

An interesting investigation is now being made at the Midwest Research Institute into the possibility of using the principle of electrostatic forces to develop a fatigue apparatus to simulate the sonic fatigue to which panels are exposed in actual operation. In this approach, pressure waves are simulated by electrostatic attracting forces between an electrode and a test panel, the magnitude of the attracting force being dependent on the voltage difference between the electrode and the panel. A suitable variation of the voltage difference can be made to represent the acoustic environment to which panels are exposed.

To create pressure waves representing a noise level of 160 db., or to fatigue a honeycomb sandwich panel 0·75 in. thick measuring 20 × 20 in., it is necessary to produce an electrostatic field of approximately 400,000 V./cm. The field should be time varying, either periodic or random. For random excitation, because of the frequency doubling effect of the tester, a frequency spectrum half as wide as that of jet engine noise is required.

The response of rectangular honeycomb sandwich panels with given boundaries to random loading can adequately be obtained by analysis, particularly when the response concerns only the lower modes. That only the lower modes are of real consequence has been observed during experiments, and follows from the fact that panels become relatively stronger when forced into the higher modes of vibration. From the noise spectrum and the response characteristics of the panel, the history of load fluctuations on infinitesimal sections of the panel may be obtained. It thus seems appropriate to evaluate the fatigue properties of honeycomb sandwich panels when exposed to jet engine noise by duplicating load variations on pertinent infinitesimal sections of honeycomb sandwich panels.

This article has been abstracted from W.A.D.C. Report No. TR 59-231, entitled "Development of a Fatigue Testing Apparatus for testing Honeycomb Sandwich Structural Panels in Service-simulated Sonic Fatigue".

NEW IDEAS IN DESIGN

Outstanding products in current manufacture

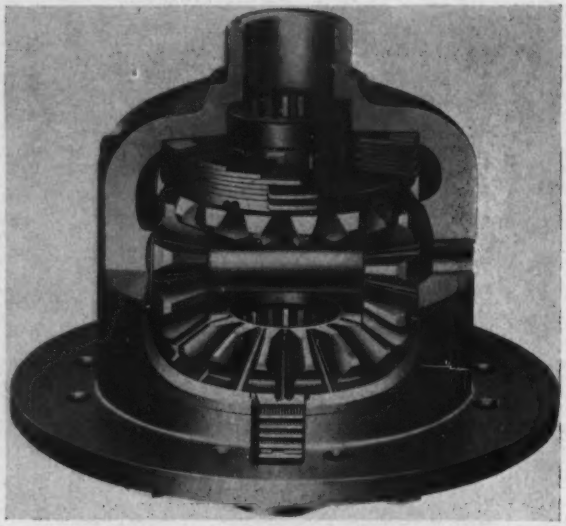
Limited Slip Differential

THE E.N.V. Engineering Co. Ltd. announce that, by arrangement with the Eaton Manufacturing Co., U.S.A., they are now able to offer the Eaton Trac-Aide controlled slip differential. This unit has been developed for use in passenger cars and light commercial vehicles. Outstanding features are simplicity of construction and manufacture, absence of lock-up peaks in operation and freedom from other than normal maintenance in service. It is of compact design, having the same overall dimensions as a conventional bevel-type differential of equivalent torque capacity, with which it can be made interchangeable.

The casing is of one-piece construction with two planetary pinions and two sun wheels similar to conventional designs. The principle is equally applicable to four-pinion layouts. Resistance to turning of the sun wheels due to lack of adhesion of either of the driving wheels is effected by clutch plates of special design and a thrust ring introduced between the thrust faces of the sun wheels and the differential casing. Steel clutch plates are used having alternately smooth surfaces and specially treated dimpled surfaces of patented form and construction. The smooth plates have internal splines which engage mating splines on the outside diameter of the sun wheel bosses, and the friction plates are provided with driving tabs which engage in slots in the differential casing. The combination of surfaces of the clutch plates has been developed to provide a consistent coefficient of friction under all conditions. Any of the lubricants normally associated with final drives can be used.

The separating forces between the planetary and sun gears tend to compress the clutches according to the torque to be transmitted, and the freedom of the differential to rotate is thus controlled. In service, the Trac-Aide is said to be remarkably free from chatter under all conditions. The accompanying illustration is a part section showing one of the clutch assemblies between the differential side gear and differential casing.

The amount of friction, and thereby the slip limitation, is



determined by the design and construction of the clutches, and is such that the Trac-Aide, besides giving the more obvious advantage of avoidance of spinning of one of the driving wheels in snow, ice or other adverse conditions, has no effect on the steering qualities of the vehicle, but rather actually improves road-holding, and reduces high-speed swerving and the tendency to skid on curves.

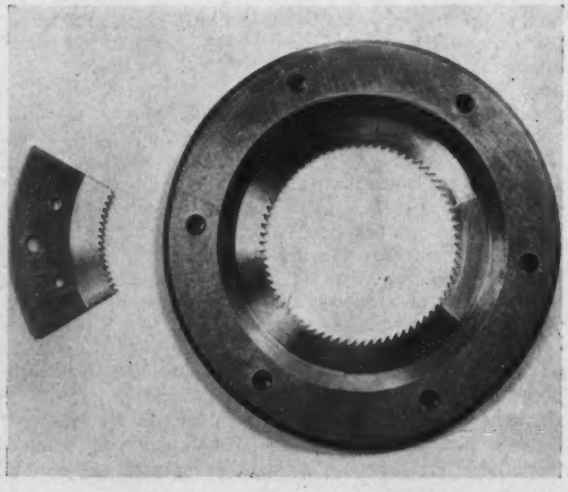
E.N.V. Engineering wish to emphasise that at the present stage they are unable to offer Trac-Aide differentials as replacements for conventional differentials in existing vehicles, but negotiations are in progress with vehicle manufacturers with a view to these differentials being offered as standard or optional equipment on new vehicles.

Unique Circular Saw

A UNIQUE circular saw with teeth where the centre hole normally is has been patented by the Manchester engineering firm of Sir James Farmer Norton & Co. Ltd., and a prototype has been made for them by Spear & Jackson Ltd., the Sheffield sawmakers. This prototype is undergoing further exhaustive trials before being put into production later in this year.

With the orthodox externally-toothed circular saw, a "flash" or uneven fragment of material is always left at the end of the cut, and this—in the case of metal—has to be filed away. This operation is unnecessary with the new machine, and a great deal of time is thus saved when cutting tubes or bars.

The teeth of the new saw are in six segments, all of which are fitted together and screwed into position to make the circular blade of the saw. The machine revolves eccentrically round the article to be cut and, of course, the cut is finished on the inside and not the outside, as is the case with a conventional circular saw.



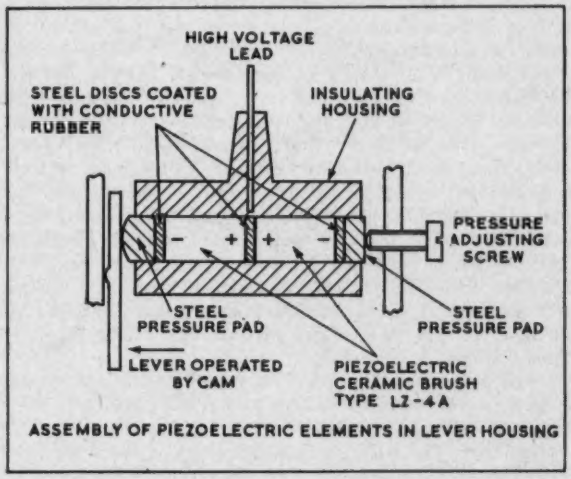
Spark Pump Ignition System

THE PZT ignition system is a newly developed device which generates high voltage for sparking petrol engines. In its present configuration the system consists of two components—the "spark pump" which furnishes the electrical energy, and a timing switch which directs the energy to the spark plug at the proper time.

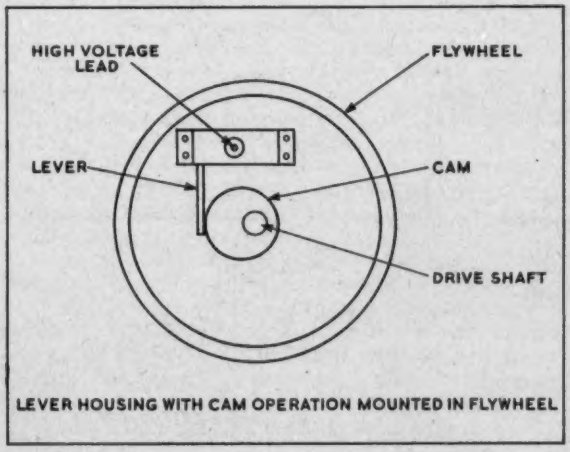
The operating principle of the spark pump is based on piezo-electricity. While a number of crystals, both natural and synthetic, exhibit the piezo-electric effect, the spark pump elements are made of PZT* ceramic, and are encased in a plastics container which in turn is supported within a stamped-metal housing. The housing also supports the actuating lever mechanism and provides a means of attaching the pump to the engine. In its present form, the spark pump occupies about 3¼ cu. in., and weighs 8 oz.

At present, the PZT ignition system is being used on small single-cylinder engines of both the two- and four-cycle type. In such adaptations, the spark pump is mounted on the engine and is actuated by an eccentric on either the crankshaft or engine camshaft. The switch, of glass-reinforced plastics, is driven by the flywheel. High-voltage ignition wires are used to connect the pump, switch and spark plug. No capacitor, breaker points or spark coil are needed.

The force required to actuate the spark pump depends upon the voltage required, the ceramic size and the leverage ratio used. Since the actual compression of the ceramic elements is small, the required force can be reduced at the expense of distance travelled. Present designs use a leverage multiplication of 15:1, acting on ceramics of 0·375 in. dia. A typical lever would require a static force of 80 lb. As speeds increase, the dynamics involved cannot be neglected, and must be considered when designing the eccentric actuating mechanism.



ASSEMBLY OF PIEZOELECTRIC ELEMENTS IN LEVER HOUSING



LEVER HOUSING WITH CAM OPERATION MOUNTED IN FLYWHEEL

In mounting the spark pump on the engine, a location away from high-temperature sources is desirable. Best results are obtained if the ceramic elements are maintained below 121 deg. C. The minimum temperature for satisfactory ceramic life has not yet been determined.

Because the PZT system works on a different principle from other ignition systems, its characteristics are also different. For example, the voltage developed is relatively constant over the range of engine operating speeds, resulting in easier starting and better high-speed spark development. For a given ceramic, the voltage depends upon the stress applied. With the ceramic elements now being used in the spark pump, voltages as high as 30,000 can be obtained. However, to keep operating stresses within a safe range, 16,000 to 21,000 V. are being used. This corresponds to an average stress of 7,000 p.s.i. The ultimate ceramic life at this load has not been determined, but is known to exceed 500 hr. at 3,600 r.p.m. of the pump actuating cam.

Principle of Piezo-electricity

When a piezo-electric material is subjected to mechanical strain, an electric charge appears across selected electrode faces. Similarly, there is a motor effect when an electric charge causes an alteration to the physical dimensions of the material.

All mechanical structures possess resonant modes of vibration corresponding to their physical properties and structural dimensions. At these resonances the strain produced by the applied vibrating force rises to a maximum due to the standing wave distributions. When a piezo-electric resonator is energised by an applied voltage of a frequency corresponding to a natural resonant frequency, then the maximum mechanical deformation will be produced.

Thus, a system can be devised consisting of two piezo-electric elements physically coupled together in a form where strain can be introduced into one element by electrically energising the other. The strain is converted back to an electrical output by the direct piezo-electric effect.

* *Lead zirconate titanate (manufactured by Brush Crystal Co. Ltd.).*

OVERSEAS NEWSLETTER

A monthly digest of reports from our foreign correspondents of other countries' current achievements in research and development work

New High-temperature Inorganic Material

Fundamental research on new forms of inorganic materials has led to the use of fibrous potassium titanate for high-temperature applications. This material, under the name of Tipersul, is now being marketed by E. I. Du Pont de Nemours & Co. (Inc.).

The fibres are produced in the form of irregular masses or lumps, and may be exfoliated to give a water-dispersible pulp from which papers, sheets and blocks may be made. In most cases these forms have adequate strength without the use of binders. The normal density of formed pads is about 12-15 lb. per cu. ft.; higher density blocks (70 lb. per cu. ft.) can be made by pressing and drying under pressure. The melting point of the fibres is 1,370 deg. C., the useful limit for the material being about 1,095-1,205 deg. C. In block form at a density of 12 lb./cu. ft. a transverse strength at room temperature of 18 p.s.i. is obtained, the thermal conductivity being 0·38 at 260 deg. C. Because of the high refractive index, compacts of the fibres cause a high degree of scatter to infra-red radiation; electrical resistivity at 34 deg. C. is $3{\cdot}3 \times 10^{15}$. Applications for the material include: insulation (thermal, acoustic, electrical and ablative); infra-red reflectors; gaskets and packing; filters; and resin reinforcement.

Self-supporting Piping Bridge

A self-supporting piping bridge with a span of 164 ft. has been specially constructed for a new oxygen plant, and is the subject of a Czechoslovak Patent. Compared with the lattice structure originally planned for carrying electric cables, pipelines for cooling water, compressed air, oxygen and steam, and piping for other less important services, the new self-supporting piping bridge is 42 per cent lighter in total weight of steel used. It is also 50 per cent cheaper in cost, and saves about 25 per cent in construction and assembly time.

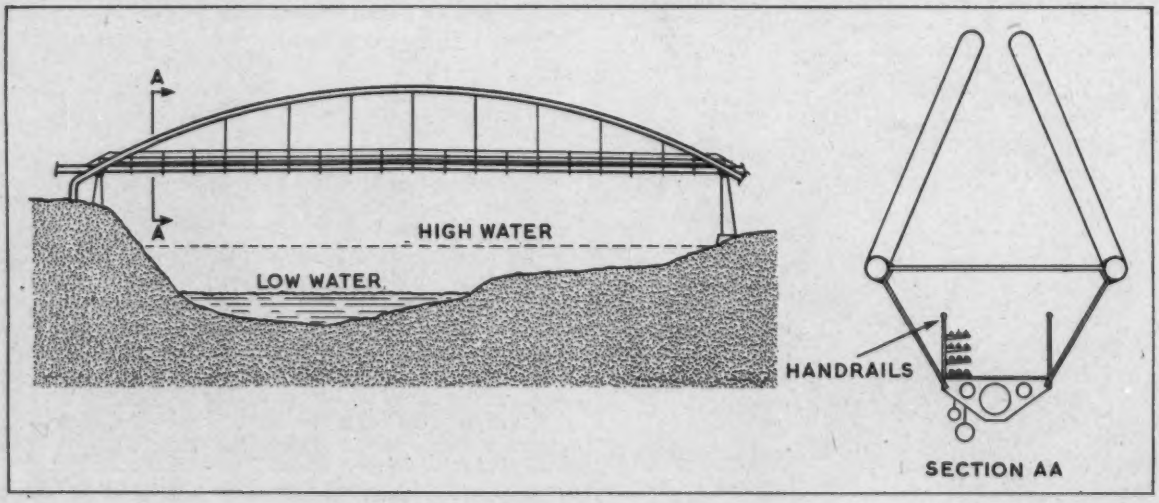
Two 15-in.-dia. tubes conveying cooling water to the oxygen plant form the two parabolic arches, which are symmetrically inclined towards each other in such a way that the straddling at the base level is about 20 ft., and the distance between the two arches at the crown nearly 2 ft. Another tube, 20 in. in diameter and conveying compressed air, forms a chord tie that is connected to the arches partly by tubular suspensions, and partly by simple flexible hangers. The chord tie carries a railed footbridge with a total width of approximately 6 ft. This footbridge carries on one side twelve electric cables mounted on standardised unit-assembled sheet-metal brackets fastened direct to the railing posts; the other side serves as a sidewalk for maintenance purposes, on which other smaller industrial pipelines can be placed. A 12¾-in.-dia. oxygen pipe and a 6-in.-dia. steam pipe are suspended below the footbridge.

The whole structure is supported by fixed foundations on one side, and by roller bearings placed on concrete posts on the other. The structure is welded, and the surface protected against corrosion by an aluminium plating.

Spiral Balance Springs

A recent German invention relates to a process for producing self-compensating balance springs for clocks or similar instruments from Ni-Fe alloys which are subjected to a tempering treatment. Processes already known for self-compensating balance spiral springs mostly relate to processes in which, by alloying with additional metals, springs of the known Invar type are produced. These springs do compensate for temperature variations, but because of their low elasticity modulus they are insufficiently stiff and can cause positional errors. Processes which have already been used include one in which nickel-iron-chromium alloys are mixed with a hardenable substance, such as beryllium, titanium, molybdenum, etc., and then tempered by the use of a precipitation hardening treatment; balance springs produced from these alloys have a higher modulus of elasticity than the Invar type.

A further process is based on a Ni-Fe alloy, containing similar precipitation hardening components, which is solution annealed, quenched, cold-rolled to strip and finally normalised. The alloying substance and hardening sub-



stance are evenly distributed throughout the alloy, so that the centre of the spring has precisely the same hardness as the edge zones. Therefore, this kind of spring can only reach certain limits of elasticity which must not be exceeded. Springs made using this process give less damping of the movement than springs of non-hardening steels.

The purpose of the present invention is to produce balance springs, based on Ni-Fe alloys, which have the favourable properties of high modulus of elasticity and the slight but necessary damping required, as well as the ability to compensate for both temperature changes and errors of position. These springs are characterised by the fact that only the surface of the spring strip is enriched with the hardening components by the thermal dissociation of a volatile compound of the metal and diffusion annealing. In addition, the balance springs produced by this new process differ from the conventional springs produced by the alloying process in that the hardening additives for the alloy are no longer uniformly distributed over the whole body of the spring, but have penetrated into the surface only by metal diffusion, and are concentrated in a boundary layer. As a result, precipitation hardening occurs only in an edge zone, and the springs have a soft core but a hard surface. The soft inner layer, which has a low modulus of elasticity, is thus sheathed with a very hard outer layer with a high modulus of elasticity, the whole balance spring having the character of a tubular spring, which, with a high stiffness and high modulus of elasticity, is resistant to fracture and has a compensating action.

The process is particularly applicable to balance springs, but can also be applied to other springs produced, using a wire or strip-form basic metal alloy.

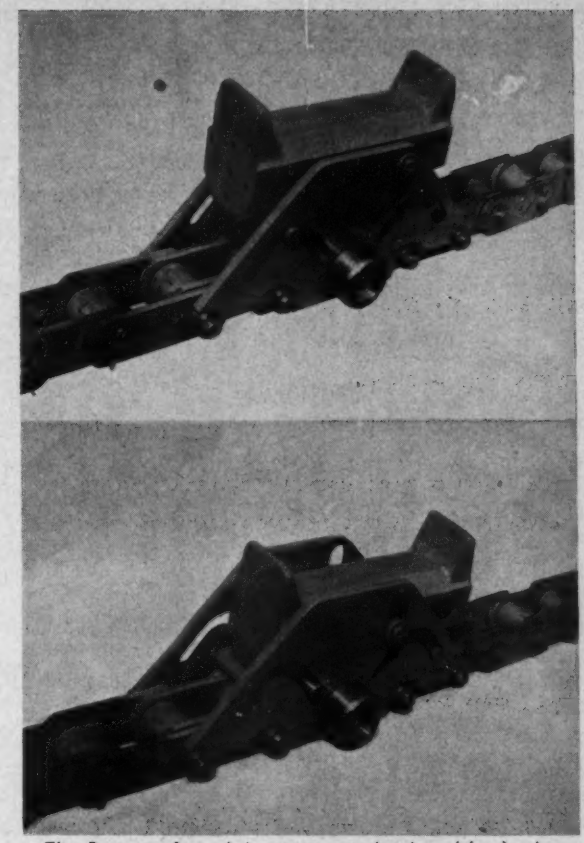
Measuring Ultra-low Pressures

A new laboratory tool for the measurement of pressures less than one-thousandth of one-billionth of atmospheric pressure at the earth's surface has been developed at the research laboratories of Westinghouse Electric International Co. This device, known as a photomultiplier ion gauge, was developed as part of an ultra-high vacuum research programme supported by the U.S. Atomic Energy Commission, and has advantages over conventional low-pressure measuring devices for many critical ultra-high vacuum experiments.

Conventional instruments measure extremely low pressures by placing electrical charges upon the gas particles remaining in a vacuum system, and counting the rate at which these charged particles or ions form from electrons that are boiled off the surface of a hot tungsten filament located inside the vacuum system in contact with the gas being measured. In many instances the gas interacts with the hot filament surface, breaking the gas down and converting it to an entirely different substance. Thus the very act of measuring the gas pressure contaminates the gas and upsets the entire experiment.

The new pressure measuring device overcomes these undesirable effects by dispensing with the heated filament, and using instead a beam of ultra-violet light to ionise the gas. The light is focused on to a metal surface which has the ability to release electrons under the stimulus of the ultra-violet rays, these electrons being subsequently guided on to a series of similar surfaces which multiply the electrons in speed and number—hence the name photomultiplier. These electrons are then used to form the ions that are collected and counted in the usual fashion.

The gauge is linear, and indicates pressure over the range from one-thousandth (10^{-3}) to one-tenth of one-billionth (10^{-10}) mm. of mercury. This range of pressures is equal to that encountered in space at distances between 50 and 650 miles above the surface of the earth, and the new device is already being used in pressure measurements and experiments aimed at understanding the concentration and interactions of the particles found in outer space.



The Brauns safety chain conveyor, showing (*above*) the normal position, and (*below*) the lugs in the slipped position.

Slip Chain Tramway

The Brauns slip chain tramway or conveyor fulfils the need for a safety chain conveyor which will continue to run without damaging either the skips or the system after there has been an accident or mechanical trouble. To achieve this, the impact between the lugs on the conveyor and the skips is reduced to a minimum by means of a spring-loaded housing.

The lugs engage with the axle of the skip, but when the load is excessive the housing slides backwards along slotted guides in the side plates so that the lugs pass beneath the skip axle. The vertical forces are such that the lugs always return to the upper position when the load is removed. It is possible, through a suitable design of the lateral guide slots, to adjust the ratio between the driving force and the impact force to an optimum level.

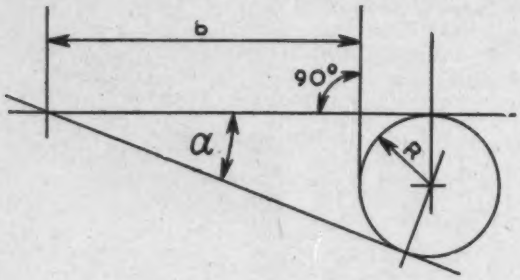
The normal force of the engaging tongue is of the order of 220 lb., which is sufficiently small to prevent any chance of derailing small empty skips. Practical experience in operation has proved that the normal contact force with empty skips of 240 gall. capacity enables them to be moved up gradients of about 3½ : 1 without trouble. The slip chain is not only suitable for the transport of skips, but also for conveying large single articles.

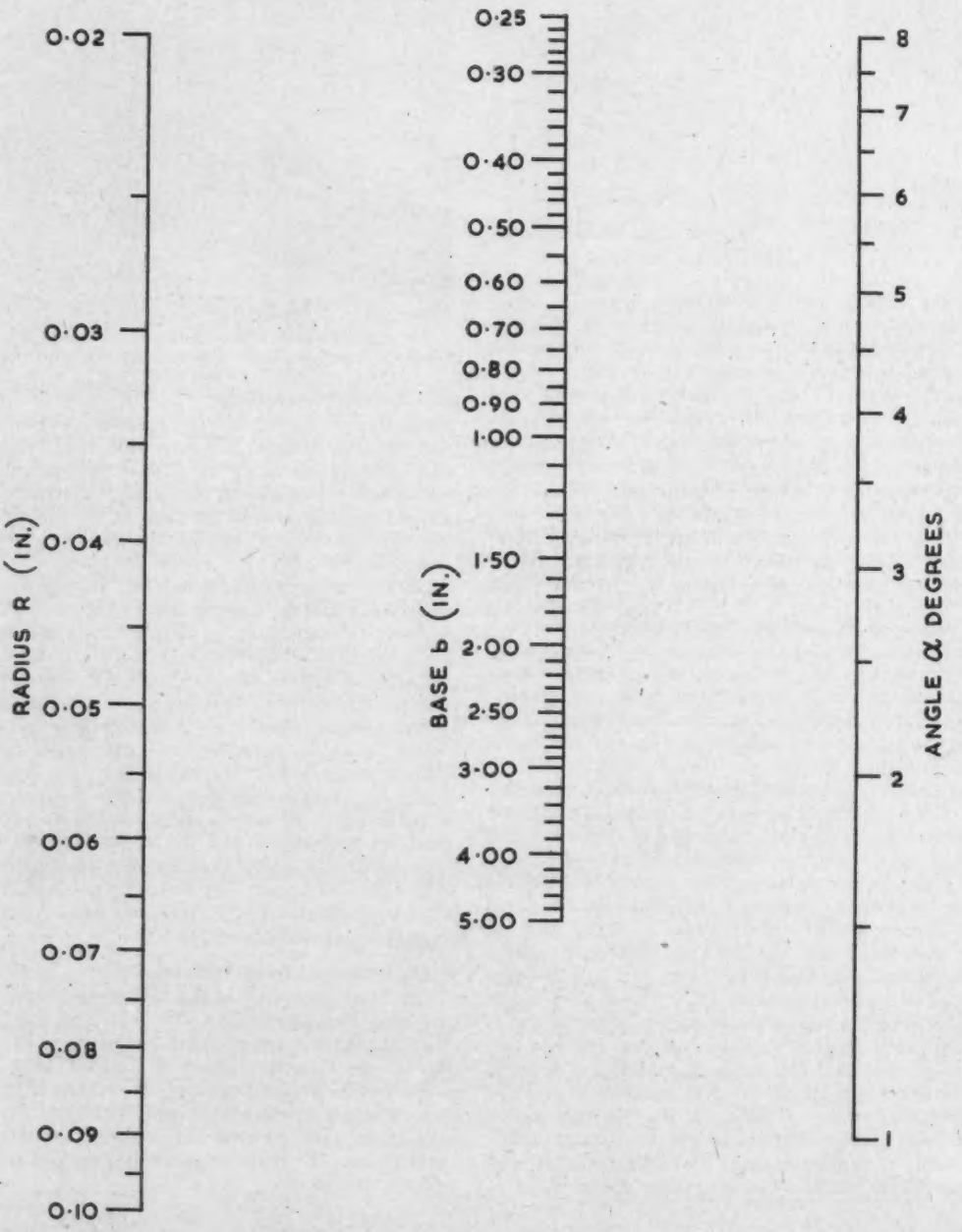
High-temperature Dielectric

The development of a new high-temperature permeable dielectric designated CMA-415, which is able to operate continuously in a temperature environment exceeding 200 deg. C., has been announced by Custom Components Inc, in the U.S.A. This dielectric is formulated from powdered iron in a special resin-base, and is suitable for operation as a microwave absorber in modern and exotic circuit applications. The material is easily moulded or machined to close tolerances.

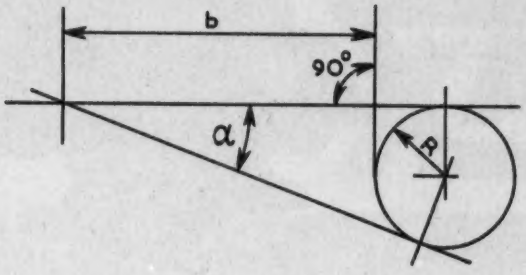
NOMOGRAMS FOR RADII AND TANGENTS

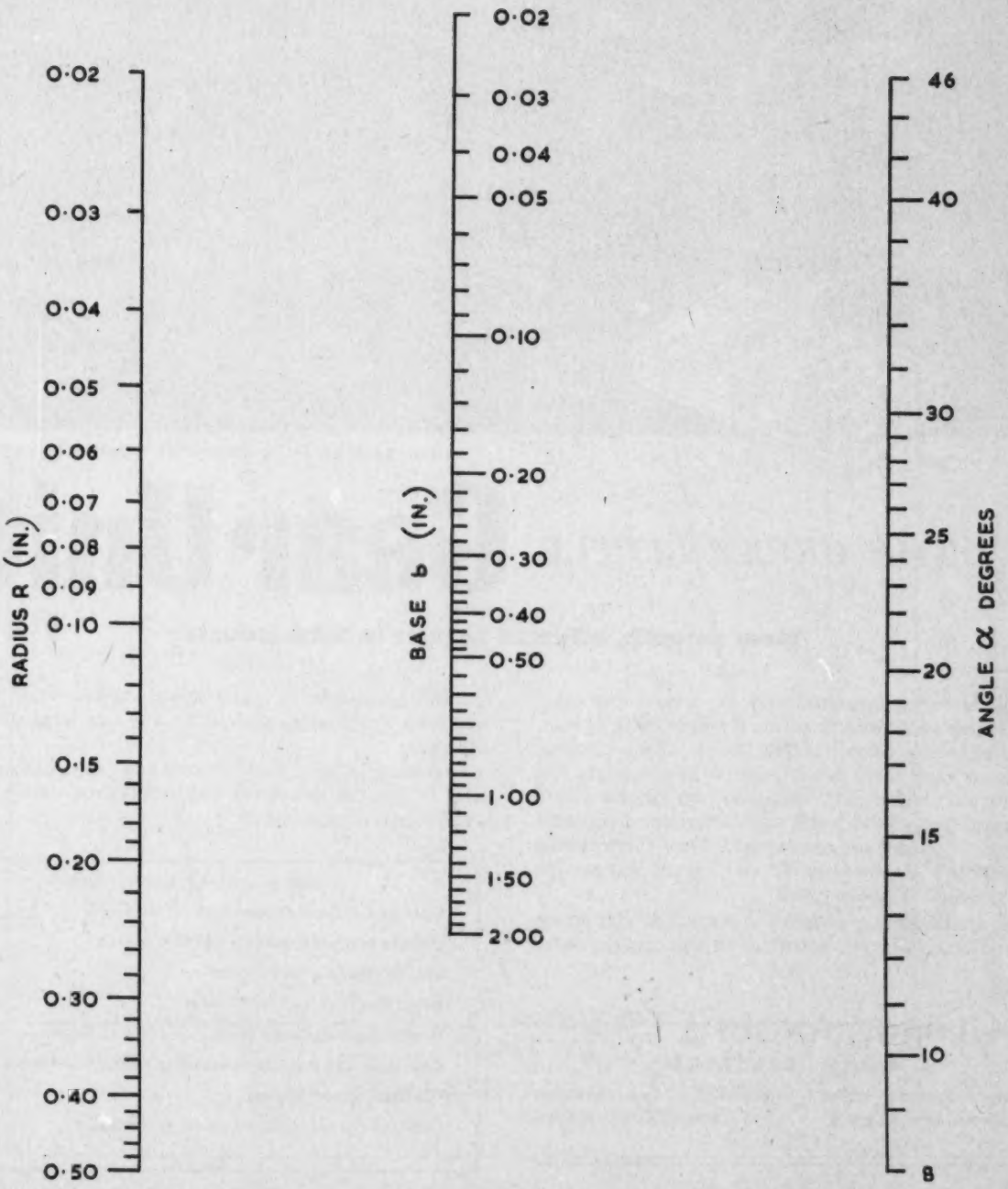
Engineering Materials and Design
DATA SHEET No. 58





NOMOGRAMS FOR RADII AND TANGENTS (cont.)





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One of the hundreds of Gamax Gear Units installed in the factory of W. D. & H. O. Wills.

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gives smooth, efficient service in light industry

For packaging cigarettes and for almost any other light industrial tasks requiring a range of ¼ to 1½ max. H.P. (18-896 r.p.m. output speed) these compact Gamax Gear Units excel. Incorporating straight line drive with high quality Durangus non-metallic planet pinions they provide really silent, vibration-free operation . . . *and because conventional oilbath lubrication is completely dispensed with, all fear of leakage or contamination is eliminated.*

The sealed bearing assembly is prepacked with grease to ensure at least two years trouble free running under normal conditions . . . and these compact units can be mounted at *any* angle without in any way impairing their efficiency.

Competitive in price, these outstanding gear units are available to give efficient, quiet and trouble-free service in any light industrial application.

ALSO IN REGULAR PRODUCTION ARE:—

Spur and Helical Gears up to 78" diameter.

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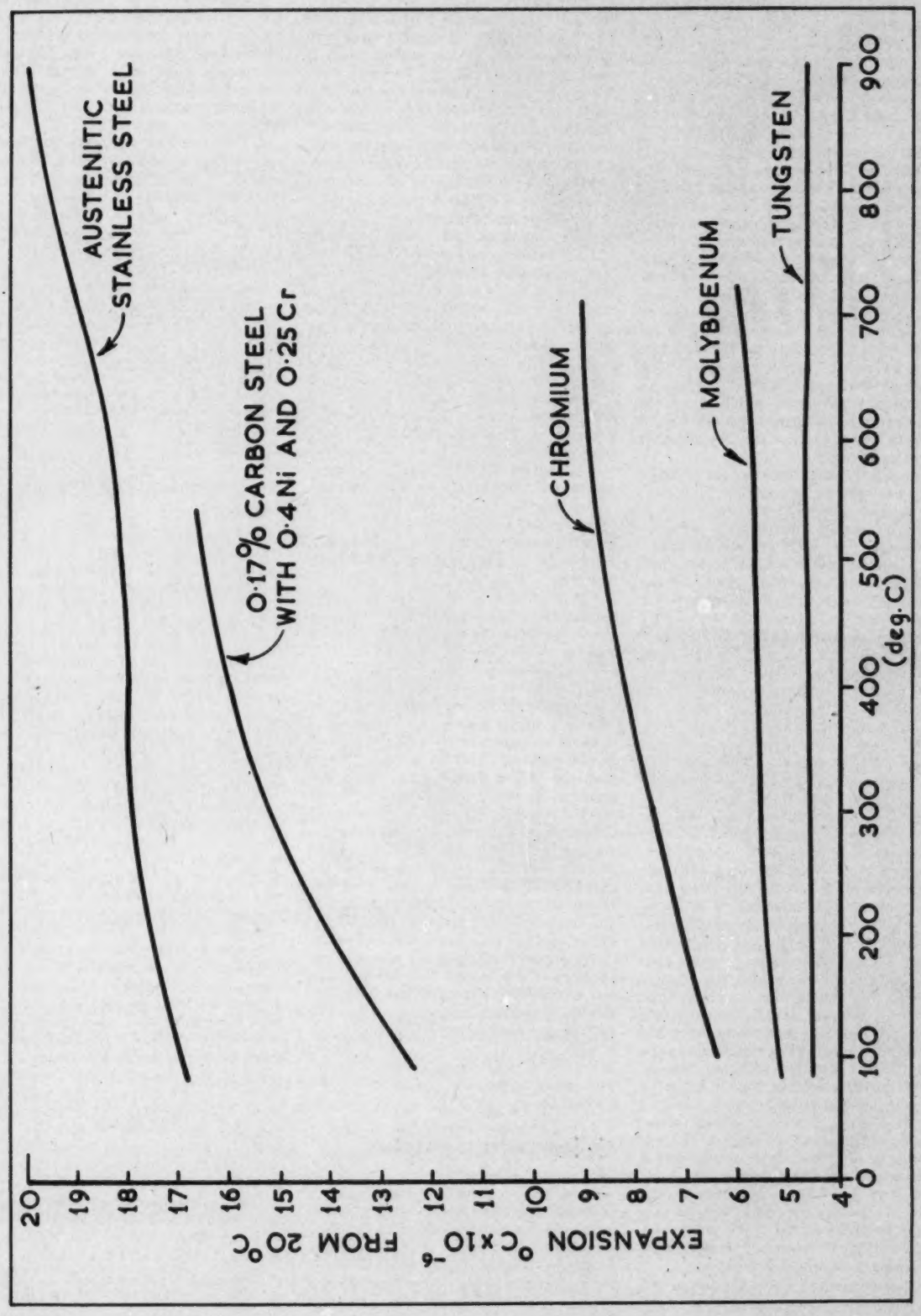
A53/60

COMPARISON OF THE LINEAR EXPANSIONS OF FIVE MATERIALS

Engineering Materials and Design
DATA SHEET No. 59



LETTERS TO THE EDITOR

Fuel Cells

Sir,

I have read your Leader entitled "Fuel Cells or Steam Engine?" in the January issue with great interest.

At the present time there seems to be a dilemma which is holding us back, in this country, from embarking on a large-scale research and development effort on fuel cells; briefly, this dilemma is that, up till the present time, the only batteries of any size which have been publicly demonstrated have been, we believe, operated essentially on hydrogen and oxygen gases, whereas most of the potential users tell us they must have batteries which will operate on hydrocarbon fuels and air. A large amount of excellent work is being done in the U.S.A., the U.K. and on the continent of Europe on cells of the latter type, but the problem is a far more difficult one than the development of a hydrogen/oxygen cell, and I do not think that a unit with an output approaching 1 kW., and which genuinely consumes a hydrocarbon and air, has so far been described. How can this dilemma be resolved?

A number of suggestions could be made —for example the conversion of hydrocarbon fuels into pure hydrogen—but it is not yet certain whether they will bear close scrutiny from the commercial angle, and a definite answer will not be obtained for several months from now. In the meantime, however, I am convinced that it is wrong to dismiss the hydrogen/oxygen cell as an interesting scientific toy, as it is likely that the performance, both on a weight and space basis, will be many times greater than that of a hydrocarbon/air cell.

You mention that the type of cell which we have been working on in Cambridge operates at 200 deg. C., and is therefore not practicable for road vehicle application, owing to the warming-up period required before starting. This may be true at the present time, but on the other hand other workers have shown that cells working on pure hydrogen and oxygen can be made self-starting from cold, provided sufficient attention is given to the catalytic activity of the electrodes; and moreover, this activity is unimpaired over many months of use, provided that pure gases are used. Activation of electrodes is an aspect of the work which for various reasons we have rather neglected until quite recently, but recent work has shown that great improvements can be made in this direction with our type of porous nickel electrode. And it must be borne in mind that all practical batteries must operate somewhat above atmospheric temperature in order to make it possible to get rid of the waste heat which is generated internally when on load; so it may be that a compromise will finally be found, for example a battery which is self-starting from cold, and which will quickly warm up to an operating temperature of say 100-150 deg. C.

The control gear necessary for a cell of our type has sometimes been criticised on the grounds of excessive volume and cost, but the equipment used in the laboratory was purposely built to give the greatest degree of flexibility for an experimental programme, and could undoubtedly be made a great deal smaller. Moreover, the system used is capable of controlling a very large battery, probably of several hundred kilowatts output, and would then form a very small proportion of the whole installation, with regard both to volume and cost. Further, we believe that no other team of workers has yet faced up to all the details of control of a battery developing a number of kilowatts continuously.

With regard to your point concerning the achievement of a very high cell output, measured in amp./sq. ft. of electrode, I myself have always believed that this is vital for a unit which is to be used for propelling vehicles; surprisingly high current densities have been shown to be possible with certain types of hydrogen/oxygen cell, and I believe that this feature will be essential if reasonably low weight, volume and cost are to be attained. Cell thickness is, of course, of equal importance in this respect.

It is heartening that the major oil companies and the larger battery-manufacturing companies are now doing some first-class work on fuel cells, although, as is well known, the research in the U.S.A. is on a far greater scale than it is in this country.

The National Research Development Corporation, which has been financing our work here for nearly four years, is actively endeavouring to obtain the support of British industry, but in the meantime has taken the decision to terminate the programme on the hydrogen/oxygen fuel cell, which means that the team of workers is unfortunately being dispersed. In the event of a British company being prepared to join with N.R.D.C. in a programme on this type of cell, the work will be restarted. However, this would depend upon evidence being forthcoming which would show that the design had market potential, bearing in mind the capital cost, fuel costs and the problems associated with the storing of hydrogen and oxygen; during the months to come, these problems will receive close attention.

We are still searching for a specialised application, for which the economic factor is not the overriding consideration; this might provide the key to a genuine commercial application later on.

F. T. Bacon

Marshalls Flying School Ltd.,
The Aerodrome,
Cambridge.

An Open Letter to Inventors

Sir,

Three major American manufacturers of automobile parts have started an active search in Europe for technical developments for which they can obtain the American licence rights. They are currently manufacturing some parts by the French Ugine-Sejournet hot extrusion process, and other parts by a German cold extrusion process. This has made them realise that European inventors may have developed other processes or products adaptable to the American automobile industry.

We announce that, on behalf of American Metal Products Co., Kelsey-Hayes Co. and the Sparton Corp., we are currently looking for patented products and processes of European origin. These three companies have total annual sales of more than $265,000,000, and are three of the most important American automobile part manufacturers.

Executives and engineers of Sparton and American Metal Products will be in France, England and Germany during March. The director of research for Kelsey-Hayes was in England, France, Germany, Switzerland and Italy last month. Between visits, the engineers in our Geneva office make preliminary evaluations of the developments submitted to them by European manufacturers and engineers. Most licence agreements that are eventually concluded deal with technical developments which are already in use in Europe but which represent an advancement over the current American counterpart.

International Research Consultants Inc.
4 Place du Molard, Geneva, Switzerland.

Marmalade—Material of the Future?

It is not generally realised how closely marmalade approximates to the ideal material for which engineers, and aircraft constructors in particular, have been searching for years. Now that the virtues of composite materials are being realised, we must expect to see a rapid increase in the use of this valuable natural material. The tough fibrous strands intimately dispersed in the flexible and resilient matrix make marmalade not only suitable but indeed ideal for every conceivable purpose.

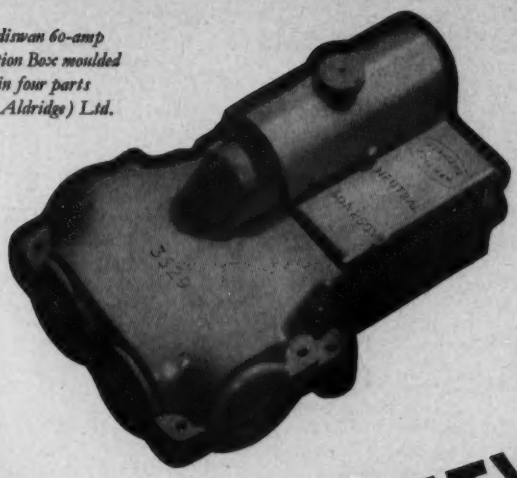
Whether considered as a paint or a paint stripper, a roofing material, cement or concrete, a honeycomb core or skin, an adhesive or merely as a metal of quite unusual type, marmalade has everything to commend it.

Of course, certain minor modifications may be needed, depending upon the exact purpose for which it is required. Thus, for replacing the ice in a skating rink it would probably require to be frozen. When used for the manufacture of safety razor blades it would be necessary to arrange the fibres parallel with the edges. Modification of the basic properties is possible in various ways, but probably the simplest is the replacement of the fibres or the matrix, or both, with other materials more suited to the purpose in hand. Thus, magnetic properties could be provided by the substitution of steel, while lightness could be achieved by removing the ingredients and leaving a vacuum.

The modern aircraft engineer will not need prompting in order to modify this valuable material to suit his purpose.

This item, which is reprinted by permission of the Magnesium Industry Council, was originally published in the Winter 1960/61 issue of *This is Magnesium*.

Siemens-Ediswan 60-amp Input Junction Box moulded in D M C in four parts by AEI. (Aldridge) Ltd.



DURABILITY for DMC

Good-looking grille on Morphy-Richards Fan Heater is a moulding by Crystalate (Mouldings) Ltd. in a special "thin flash" grade (L.1834) of Beetle D M C.

Wolf "Safetymaster" Power Tool. D M C mouldings by Minerva Mouldings Ltd. are ingeniously designed to provide double insulation.

Beetle Polyester D M C is equally outstanding for its electrical insulating and anti-track properties as for its high heat resistance and mechanical strength. That's why it is unbeatable for high-duty applications, of which the examples shown are typical. D M C is economical because it is fast-curing and simple to mould under low pressure in conventional compression and transfer presses. Compatibility with metals and dimensional stability are above normal for thermosetting materials.

Two glass-filled types are available: Type A for general purpose and electrical components; Type B, a self-extinguishing material. Also Type C, an economical sisal filled compound. Write for full details.

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New Books

The Electro-erosion Machining of Metals. *By A. L. Livshits. (Butterworths Publications—30s.)*

This book, based upon Russian investigation into electro-erosion processes, gives an up-to-date and complete exposition of the state of development of these techniques. Covering electro-pulse, electro-spark, anodo-mechanical and electro-contact methods of metal machining, the author attaches most importance to that of electro-pulse as having the greatest application potential, and better technical and cost characteristics than those of the electro-spark. Descriptions of pulse generators with typical diagrammatic circuits are provided, and the phenomena associated with each type discussed in detail.

Particularly interesting are the chapters devoted to the determination of the electro-technological characteristics of electro-erosion machining relating to the rate of metal removal, area, shape, current, etc.—bearing in mind that these techniques are not yet fully developed. Difficulties encountered in the mechanical production operations, e.g. grinding, die-sinking and slitting, are probed, and comparisons drawn between the mechanical and electro-erosion methods of overcoming them. Although obviously biased in favour of the latter method, the author does not hesitate to give its defects and limitations, particularly with reference to surface finishing.

Electro-erosion machines, their sources of energy, comparative efficiency and stage of development, are thoroughly examined, and illustrated with relevant circuits and explanatory diagrams.

A. H. Roach

Processing of Thermoplastic Materials. *By E. Bernhardt. (Reinhold; Chapman & Hall—146s.)*

The value of this book extends beyond the field suggested by its title. It is the work of some twenty authors, drawn from industry and universities, and within its 690 pages and three sections presents a considerable quantity of useful information. The intended scope is defined as "The design and operation of various processes for . . . altering plastics materials in order to increase their utility".

English readers will probably gain most from the fundamental and, where necessary, mathematical treatment given to basic aspects of process plant design in the first section. This section comprises three chapters headed respectively "Flow Behaviour", "Heat Transfer and Thermodynamics" and "Mixing and Dispersing". These chapters are very good, and are worthy of study by any engineer designing process machinery for plastics or related industries.

The second section describes, often with the aid of mathematical expressions, the various processes available, including extrusion, injection moulding, calendering, mixing and dispersing, sheet and hollow-ware forming, and sealing and welding. Each chapter is illustrated by photographs of appropriate machinery (usually of American origin) and concluded with a list of references drawn from both sides of the Atlantic. A final section lists the properties of American thermoplastic materials in considerable detail.

In brief, this is a book vital to those working on the design of plant for handling thermoplastic materials, of considerable use to plant designers in related fields, and of interest to all engaged in the thermoplastic industry.

A. W. Thompson

The Machining of Steel. *By F. C. Lea and E. N. Simons. (Odhams Press Ltd.—21s.)*

This handbook presents in a simple and explicit form the fundamental principles of cutting and shaping steel and its alloys. Many aspects of turning, shaping, milling, drilling, broaching, reaming and sawing are covered comprehensively; grinding, however, is omitted. Detailed instructions, with diagrams, are given for setting up and operating each type of machine, together with examples of various applications and their comparative costs.

Several chapters are devoted to cutting tools, their design, sharpening and selection for specific purposes, whilst timely warnings against malpractice in the use and storage of these items are not neglected. Broad problems regarding coolants, speeds, feeds and tool wear are outlined, and a general guide provided.

Subsequent sections of the book describe, with appropriate illustrations, the uses of jigs and fixtures, and in a short but useful appendix the principle of electro-spark machining is explained.

A. H. Roach

Techniques of Non-destructive Testing. *Edited by Hogarth and Blitz. (Butterworths Publications—40s.)*

A collection of papers written originally for a series of lectures by specialists at Brunel College. Most of the chapters are self-contained and refer to one specific lecture. Additional chapters on the "Use of Radio-isotopes" and "The Thermal Comparator" have been included. The final additional chapter outlines the way in which many of the techniques described in this book are applied in a government testing establishment.

Powder Metallurgy No. 6. *(Iron and Steel Institute and the Institute of Metals —subscription 25s. p.a.)*

This book contains most of the papers which formed the basis of the recent symposium on practical aspects of pressing metal powders. Included in this were developments in metal powder presses, some fundamental studies in the cold compaction of plastically deforming solids, and the compacting of metal powders by explosives.

Polystyrene. *By W. Teach. (Reinhold; Chapman & Hall—40s.)*

This is a further addition to the Reinhold plastics application series of books intended to indicate the scope of commercial applications for polystyrene. The simplified chemistry of polymerisation of styrene is included for background information, the main contents of the book covering the various techniques of fabrication and the applications of the plastics. The properties of this material are included, together with a chapter on polystyrene foam, which has a rapidly growing field of application.

Mechanics for Textile Students. *By W. A. Hanton. (The Textile Institute and Butterworths—30s.)*

This book on elementary mechanics consists of three parts, the first of which was published separately in 1940. It is primarily intended for part-time students of textile technology, and in presenting the subject this fact has been kept constantly in mind. The author, in arranging the material, has followed the recommendations of the Spens Report on secondary education; viz. that science should deal with the students' own experience, and that a course in science should correspond with the extending interests of students. This accounts for the somewhat unorthodox layout of the book, which commences with a thorough study of movement of diverse machine elements, but leaves for later consideration the question of forces which cause movement. This is due to the circumstance that in the early stages of their studies most students are mainly concerned with kinematics of the textile machinery, and only in the later stages have to deal with problems involving force in its static and dynamic aspects.

In addition to the study of movement, the first part of the book deals with the fundamental equations connecting time, displacement, velocity and acceleration, and concludes with parallelograms of velocities.

The second part of the book deals with force, mass and momentum, and Newton's Laws of Motion. The resolution of forces, principles of moments and friction are also treated. This part ends with sections on stress, strain and elasticity.

The third part deals with dynamics, involving momentum and energy, impulsive forces, impact, the forces in circular motion, and other concepts. Further force, velocity and acceleration diagrams are discussed. Simple harmonic motion, moments of inertia, and experimental methods for finding the latter are treated. The book is concluded with an appendix containing a summary of formulæ used.

The book contains a large number of examples illustrating the concepts and principles introduced, and mostly dealing with some aspect of the processes in the textile industry. The same applies to the numerous problems presented at the end of each chapter.

W. Sirk

The Practical Anodising of Aluminium. *By W. W. E. Hübner and A. Scheltkuecht.* (*Macdonald & Evans—55s.*)

This is an efficient and completely Anglicised translation of a book published in Germany in 1956, and already very popular there. It provides the production engineer or shop foreman with essentially practical, detailed and well-illustrated instructions for carrying out not only anodising, but all the associated preliminary and subsequent treatments; for good measure it includes similar information on a number of alternative non-electrolytic processes, such as M.B.V. and Alocrom. The book is evidently based on extensive experience of the practice of anodising; a minimum of theory is given, but the authors are clearly well acquainted with this. An extensive bibliography has been brought up to date by the translator and extended with English-language references.

After a general review of the possibilities and scope of the various chemical and electrochemical processes for the protection and decoration of aluminium alloys, precise details are given for the chemical compositions, operating conditions and control processes of preliminary degreasing, etching and brightening. This is followed by equally practical instructions for the numerous different anodising solutions, i.e. sulphuric, chromic, oxalic, Ematal, and the subsequent processes of dyeing, sealing and de-blooming. This occupies about one third of the book. Another third gives eminently practical advice on plant and equipment, starting from choice of site and type of buildings, and continuing to minute details of tanks and ancillary equipment.

The remaining 100 pages deal in a similar detailed manner with mechanical grinding and polishing, methods of suspension of articles during treatment, and manipulation of special products. This section and the previous one are excellently supported by really informative line diagrams and photographs.

The book is excellently produced and bound, and will prove invaluable to novice and experienced practitioner alike.

G. E. Gardam

OTHER BOOKS RECEIVED

A History of Platinum. *By Donald McDonald.* (*Johnson, Matthey & Co. Ltd.—35s.*)

The story of platinum as seen by the refinery and fabricator engaged in commerce, covering developments over a period of nearly 200 years. Includes a history of the company.

The Determination of Gases in Metals. (*Iron and Steel Institute—63s.*)

A collection of papers given at a symposium, organised by the Society for Analytical Chemistry in conjunction with the Iron and Steel Institute and the Institute of Metals, on the methods for determining gases in metals.

Design for Metal Finishing. (*The Institute of Metal Finishing—5s.*)

A profusely illustrated brochure of design recommendations to ensure efficient polishing, plating or painting of finished products. Includes a list of the metals and alloys commonly applied as electro-deposited coatings, and the sources of technical data on finishing issued by the British Standards Institution.

Sound Absorbing Materials. *By Evans and Bazley.* (*H.M.S.O.—3s.*)

This book deals mainly with absorbents designed to reduce reverberation, and describes the measurements and tests conducted by D.S.I.R. covering the majority of proprietary materials used in the U.K., including floor coverings, tiles and boards.

Application of Atomic Engines in Aviation. (*United States Department of Commerce, OTS Report No. PB 131 908T—$3.*)

This report has been translated from the Russian, and includes perspectives for the use of nuclear reactors for aircraft power plants, and for inter-planetary flight. Contains diagrams, charts and a bibliography.

Friction and Wear at Elevated Temperatures. (*United States Department of Commerce, OTS Report No. 161 719—75c.*)

Describing the construction and use of a new high-temperature friction apparatus which allows experiments to be carried out at temperatures up to 1,100 deg. C. in controlled atmospheres.

Mechanical Properties of Selected Alloys at Elevated Temperatures, Part 2: Design Criteria of Silicon Carbide. (*United States Department of Commerce, OTS Report No. 161 723—$2.75.*)

Includes a section dealing with design parameters and areas of application for silicon carbide.

F.B.I. Register of British Manufacturers: 1961. (*Kelly's Directories Ltd., and Iliffe & Sons Ltd.—50s.*)

Contains lists of products and services of some 8,000 member firms. Includes trade-marks, information on trade associations, and French, German and Spanish glossaries of every product term used.

BS A100: 1960. (*British Standards Institution—10s.*)

General clauses for aircraft bolts and nuts.

BS S124: 1960. (*British Standards Institution—2s. 6d.*)

Dealing with 45-55-ton corrosion-resistant free-machining chromium steel for aircraft—replacing DTD 525.

BS 292, Addendum 1 (PD 3964). (*British Standards Institution—3s.*)

Specifies tolerances, in inch and metric units, for metric size precision ball and roller bearings.

BS 466: 1960. (*British Standards Institution—12s. 6d.*)

Refers to electric overhead travelling cranes, and is to be used in conjunction with BS 2573: 1960.

BS 601, Pt. 2: 1961. (*British Standards Institution—5s.*)

Deals with oriented magnetic steel sheet and strip for magnetic circuits of power electrical apparatus—includes test data.

BS 693: 1960. (*British Standards Institution—6s.*)

Applicable to oxy-acetylene welded structures other than pressure vessels and pipes. Lays down requirements for butt and fillet welds, distortion control and tests.

BS 919, Pt. 1: 1960. (*British Standards Institution—17s. 6d.*)

Gauges for unified screw threads, reconciling British and American practices. Includes recommended system of gauges for coated screw threads.

BS 2960, Pt. 2: 1960. (*British Standards Institution—7s. 6d.*)

Gives dimensions of three-phase electric motors up to 50 h.p. at voltages up to 650 V.

BS 2573: 1960. (*British Standards Institution—12s. 6d.*)

Revised edition of permissible stresses in cranes, intended to form the basis of designs for all types of cranes.

BS 3228, Pt. 3: 1960. (*British Standards Institution—3s.*)

Specifies procedure for obtaining creep properties of steel at elevated temperatures.

BS 3283: 1960. (*British Standards Institution—6s.*)

Specifies the dimensions, materials and tests for non-reversible connectors and appliance inlets.

BS 3288, Pt. 1: 1961. (*British Standards Institution—5s.*)

Definitions and general requirements of insulator and conductor fittings for overhead power lines.

BS 3289: 1960. (*British Standards Institution—5s.*)

Requirements and test methods for conveyor belting used in coal mines.

BS 3290: 1960. (*British Standards Institution—3s.*)

Details, composition, dimensions and physical properties of toughened polystyrene extruded sheets, plain and foil faced.

BS 3293: 1960. (*British Standards Institution—12s. 6d.*)

Specifies materials, dimensions and markings for welded carbon steel pipe flanges for pipes over 24 in. nominal diameter.

BS 3295: 1960. (*British Standards Institution—5s.*)

Dimensions for interchangeability of machine slides and beds for motor powers up to 25 h.p.

BS 3297: 1960. (*British Standards Institution—10s.*)

Applicable to porcelain and glass post insulators for outdoor working voltages above 3 kV.—includes test data.

On show at the A.S.E.E. EXHIBITION

EARLS COURT, LONDON, MARCH 21-25, 1961

Electrolytic Analogue

The electrolytic analogue is used to determine the initial distribution of an impulse or surge voltage applied to a transformer winding. For a very short interval of time immediately following a surge a transformer winding may be represented by a purely capacitive network, the nodes of the network being each turn of the winding, and the capacitances between nodes being those between adjacent turns, both axially and radially.

In the equipment exhibited an analogy is drawn between capacitance in the actual transformer and resistance in the electrolytic analogue model. The conductors of the model represent turns in the transformer winding, the resistance of the electrolyte between these conductors being made inversely proportional to the original capacitances. The surge is simulated by applying a potential between the line conductor and the earthed neutral, and intermediate conductors then attain a potential between these limits determined by the distribution of the resistances between conductors. These potentials are measured by a voltage divider connected between line and neutral, with a detector between the conductor under consideration and the divider's sliding contact.

The model on show represents the first eight sections of a high-voltage transformer winding adjacent to the line conductor. The divider has been made self-balancing by using a closed loop servo system, and the conductor potentials are indicated on a decade counter showing them as a percentage of the potential applied to the line conductor. Bruce Peebles & Co. Ltd., Edinburgh, 5.

EMD 6226 for further information

Glass Fibre Tube and Rod

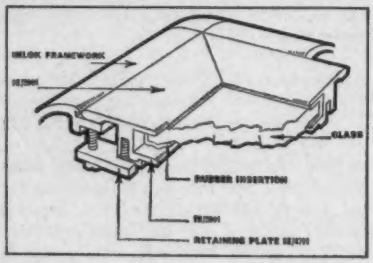
Two forms of glass fibre materials are being displayed for the first time: (a) "wave-wound" tube for arc control pots,

conduits conducting cooling air, etc., available in diameters up to 6 ft. and lengths of 20 ft. (longer if necessary); and (b) extruded glass fibre rod, diameters ¼ to ¾ in., in four colours, for use in stay wire insulators and whip aerials. Permali Ltd., Bristol Road, Gloucester.

EMD 6227 for further information

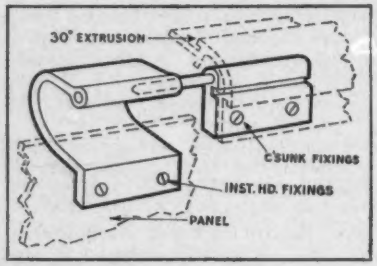
Glazing and Hinge Extrusions

A new part which further increases the versatility of the Imlok system of construction is the glazing extrusion IE/2901, which will hold ¼-in. plate glass or ¼-in. thick plywood. Special rubber insertions are supplied for glass of varying



thicknesses. The glazing extrusion is so formed that it can be attached to frameworks made from almost any Imlok extrusion; no drilling or tapping is required, so that the building of special housings with glass panels or desk-tops is now a very simple matter.

Another new part is a concealed hinge of the lift-off type, which is specially designed for heavy duty; this, too, can be used with Imlok extrusions of different



angles in order to fit doors or hinged panels with ease to practically any Imlok structure. Alfred Imhof Ltd., Ashley Works, Cowley Mill Road, Uxbridge, Middlesex.

EMD 6228 for further information

Spring-operated Disc Brake

No less than eleven special features are claimed for each of the six sizes of B.H.I. spring-operated disc brake. In brief, these features are: (a) the brakes have been designed to mount directly on to standard flanges of motors, the fixings being to N.E.M.A. I.C. 1-20-64 Specification; (b) inherently "fail safe", since they are spring applied and electromagnetically released; (c) the use of low lining pressures gives maximum life to the linings, and results in the minimum of adjustment; (d) as the brakes are completely assembled and adjusted before despatch, they can be fitted as a complete unit to the motor without the need for dismantling or adjustment; (e) easy replacement of magnet coils—only four sets of coils are needed to cover the standard voltage range and all brake sizes; (f) the brakes are designed to comply with the specifications which concern the motor and control gear, as they will function at 85 per cent of the rated voltage; (g) the brake torque is adjustable from the maximum rated figure down to zero; (h) the motor shaft can be extended through the brake to permit double-ended driving, or to facilitate the fitting of a cooling fan for the motor; (i) a hand release is fitted without increasing the length of the brake; (j) when the brake coils are energised the hand release becomes automatically inoperative; and (k) the coils are insulated to Class E insulation. Brookhirst Igranic Ltd., Elstow Road, Bedford.

EMD 6229 for further information

Universal Trunking System

This trunking is manufactured in 12 ft. 6 in. lengths in galvanised steel, and incorporates provision for up to three cable ducts. Snap-in covers are provided in the top and bottom, and any standard lighting fitting can be easily attached. A three-pin 5-amp. plug and socket, a pull switch assembly, and a fused connection box for tapping off mains for small power units can be supplied. Trunking suspension stirrups can be spaced at 15-ft. centres with full load. (All attachments will slide to any position.) F. W. Thorpe Ltd., Thorlux Works, Welby Road, Hall Green, Birmingham, 28.

EMD 6230 for further information

Infra-red Heater

A new 500-W. high-efficiency infra-red unit for domestic use, operating at the 3-micron waveband (at which the human body is most receptive to radiant heat), has been developed from the successful industrial and commercial units manufactured by this company. This appliance is guaranteed for one year, and is said to be the only unit that has a reflector which is easily removed for cleaning or replacement.

Other notable features are: a built-in pull cord switch; easy angle adjustment; a hinged guard; and a special long-life element protected by quartz tube. The unit is designed to comply with the British Standards Specifications. Thermodare (Great Britain), York Mansion, 94-98 Petty France, London, S.W.1.

EMD 6231 for further information

High-temperature Heating Tape

A wide range of electric heating tapes for temperatures up to 350 deg. C. is exhibited (type ITA is shown in the illustration). For higher temperatures, quartz cloth has been used in the past instead of glass cloth, but this is

susceptible to friction—a new development is now available which consists of a heating tape using the metal-sheathed mineral-insulated heating elements fitted to a stainless-steel mesh carrier. The terminations are at one end, and the tape is made in standard lengths between 6 and 35 ft., 2 in. wide. These can be used for operating temperatures up to 650 deg. C. Isopad Ltd., Barnet By-pass, Boreham Wood, Herts.

EMD 6232 for further information

Miniature Recorder

The Dwarf Inkwell Recorder has a 4-in. chart with case dimensions of small size enabling it to fit into a 6-in.-square cut out, occupying a panel space of only 7 × 7 in. A new design of movement gives increased sensitivity to an extent that, for the 4-in. chart width, full scale deflection can be as low as 150 micro-amp. With three pairs of gear wheels and a two-speed gearbox, six different chart speeds can be obtained. Everett Edgcumbe & Co. Ltd., Colindale Works, Colindeep Lane, Hendon, London, N.W.9.

EMD 6233 for further information

Plastics Power Cable Joint

A plastics power cable joint has been developed for use with plastics insulated and sheathed power cables. It is claimed to provide a simple, thoroughly reliable and inexpensive jointing method. No plumbing is necessary and the joint may be buried in the ground within a short time of mixing the compound, which is poured in the "cold state". The resin sets very rapidly—usually within 30 min. of mixing—and the moulds may be removed and dispensed with. Aerialite Ltd., Castle Works, Stalybridge, Cheshire.

EMD 6324 for further information

Pins, Rivets and Wires

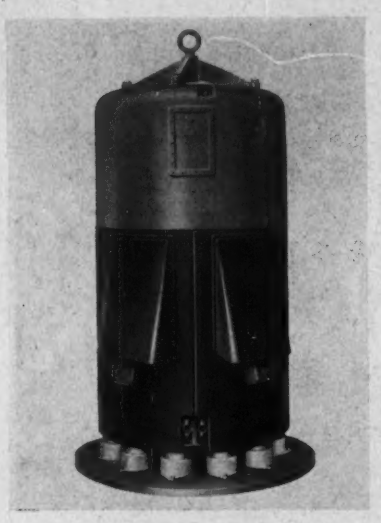
The right-hand illustration shows examples of Wire Products' wide range of precision pins, cut wires, special rivets and small gauge wire components, many of which are deburred, polished and electroplated. Wire Products & Machine Design Ltd., Kingsbury Works, Bridge Road, Haywards Heath, Sussex.

EMD 6235 for further information

10,000-c/s Motor Generator

This unit is designed for induction-heating and similar applications. The set consists of a squirrel-cage motor and an a.c. generator, with the two rotors mounted on a common vertical shaft so that the combined set occupies minimum floor space. Cooling is effected by means of a closed-air circuit incorporating a water-cooled heat exchanger. The construction, in conjunction with a carefully designed air circulation, ensures quiet running.

The set is mounted on resilient pads which insulate from vibration and render installation easy, thus enabling the machine to be placed where the supply is used, reducing the high-frequency cable



runs to a minimum. The sets operate singly or in banks paralleled to suit load demands. They can be supplied for frequencies up to 10,000 c/s, and with fast response times where quick changes of load demand rapid control of output voltage. The Electric Construction Co. Ltd., Bushbury Engineering Works, Wolverhampton, Staffs.

EMD 6236 for further information

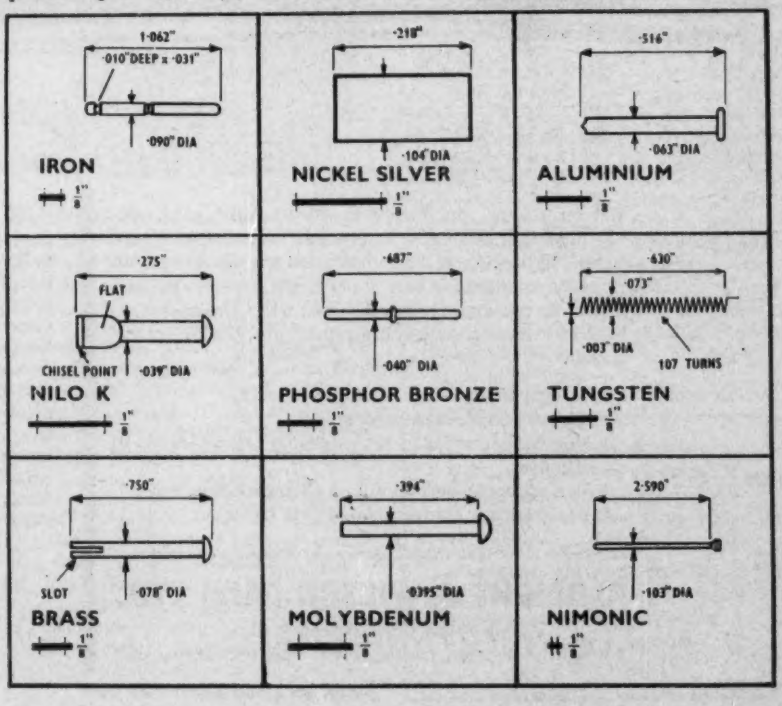
Oil Filters

The self-contained High Vacuum insulating oil filters are designed to meet requirements where an exceptionally high degree of freedom from moisture and dissolved gases is demanded, particularly in highly stressed electrical equipment. Besides conditioning the oil in the transformer, this freedom also ensures the complete elimination of small pockets of moisture and gas in the windings, which can allow re-contamination of the cores after leaving the drying ovens, or when the transformer is shipped to humid climates.

The portable P.8 insulating oil filter and pumping set is also on show. It can be operated by one man, particularly in remote and inaccessible places where there is an insufficient electrical supply to power the heater in a large filtration plant. The P.8's versatility makes it the ideal filter for cleaning oil in small electrical equipment such as transformers, circuit breakers, tap changers, and for the cleaning of oil stored in barrels or storage tanks.

Models of the range of N type filters are also displayed. These purify and dehydrate insulating oil in transformers and switchgear equipment. Slightly modified, they are equally suitable for the filtration of turbine lubricating oil, where a high degree of cleanliness is required. The latest addition to the N range is the CN.186, which is a 1,000-g.p.h. plant. Three types are manufactured: the fixed, semi-portable and fully mobile. Stream-Line Filters Ltd., Vokes Group, Henley Park, Guildford, Surrey.

EMD 6237 for further information



HETRON* RESINS

Hetron Resins, polyesters based on Het* Acid, are rapidly being acclaimed as new and versatile fabricating materials. As well as offering all the advantages of normal low-temperature-setting polyesters, Hetron Resins do not support combustion. When the source of heat is removed, flames die immediately. *Fire cannot spread.*

In addition, Hetron Resins offer fabricators:

- High strength with light weight
- Non-deterioration of fire-retarding properties in all climates
- Resistance to corrosion and chemical attack
- Resistance to temperatures up to 150°C.

Please write to us for full details of the many applications of Hetron Resins

ALBRIGHT & WILSON (Mfg) LTD.

Section HR6, Organic Chemical Dept.,
1 Knightsbridge Green, London, S.W.1. Tel: KENsington 3422

IN ENGINEERING

Glass fibre reinforced polyesters have long been used for many types of plant construction. Polyesters based on Het Acid are chemically resistant and provide the great additional advantage of being self-extinguishing. One such resin allows laminates with glass mat to retain 70% of its original room temperature strength when measured at 150°C. after ageing for 192 hours at 150°C. Such laminates are also resistant even to glacial acetic acid which attacks most other polyester resins.

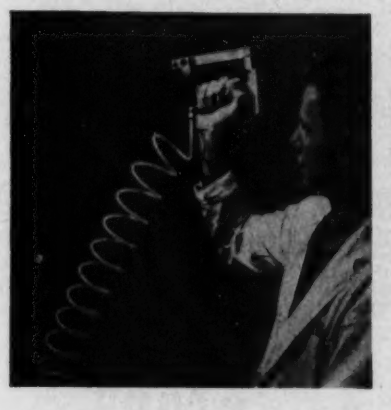
* *Registered Trade Mark*

WHAT'S NEW IN MATERIALS & COMPONENTS

Self-coiling Air Hose

Ny-Flex is a new self-coiling nylon air hose which stretches and recoils like a telephone cord. It is made of tough, durable nylon, and is claimed to resist oils, solvents, heat and abrasion. Unlike rubber hose, it is said to be unaffected by oil, so there is no flaking, etc., to adversely affect air tools.

Ny-Flex is translucent, so any moisture or impurities in the hose can be quickly seen. It is claimed to withstand working pressures of 200 p.s.i., and to have a burst pressure of four times this figure. It



extends to 25 ft., and recoils to 9 in. in length when not in use. It is easily fitted to any air installations. Senco Pneumatics Ltd., Craigton Industrial Estate, Glasgow, S.W.2.

EMD 6238 for further information

P.v.c. Counter-topping

Evergleam, a new polyvinyl chloride counter-topping material is now available in the U.K. in four designs (linen, frost, metallic and terrazzo) and a total of twenty-three different patterns. Evergleam was recently developed by Goodyear in the United States, where it met with great success. Attractive and long-wearing, it is said to be resistant to water, grease, acids, alkalis, heat and abrasion. It is easily fixed by using the usual type of adhesive for this work, and can be applied to give a fine rolled finish over the counter edge or seamless square edge facings without cracking or splitting under normal handling conditions.

Evergleam is of a laminated construction, and it is in this way that the pattern is applied. It is said to differ from other similar products in that it is more resilient, will not crack or chip, is rot- and mildew-proof because it contains only pure vinyl, and can be easily moulded to awkward contours without heat or undue pressure. It is approximately $\frac{1}{16}$ in. thick.

Other advantages claimed are the elimination of buckling or warping and pulling away from base material. Evergleam is also fire-proof, though it will melt if subjected to a direct flame. The Goodyear Tyre & Rubber Co. (G.B.) Ltd., Bushbury, Wolverhampton.

EMD 6239 for further information

Rigid Extruded Sheet

The manufacturers of Saroy toughened polystyrene now announce Sarrac, a new thermoplastic sheet developed for industrial applications. Sarrac is said to be extremely tough, and suitable for many exterior applications due to its thermal, abrasion-resistant and impact properties, and the ease with which it can be thermoformed; it is also claimed to have good chemical resistance. It is available in a wide range of sheet sizes and thicknesses. Saro Products Ltd., East Cowes, I.O.W.

EMD 6240 for further information

Crushable Plastics Ducting

Designed initially to provide a solution to a particular problem in the aircraft industry, a unique type of ultra-light-weight crushable ducting has recently been introduced. Its extreme light weight and ability to reform to contour after crushing should ensure a ready acceptance in many different industrial spheres.

The original problem, culminating in the introduction of the new ducting, was to pass a 2-in.-dia. duct, having a right-angle bend and a $\frac{1}{4}$-in. flange on either

end, through a 2-in.-dia. hole in a bulkhead panel to connect two main air ducts. Allowance had to be made for misalignment, and this was done by including a built-in nylon corrugation. No existing type of ducting was satisfactory, and after trial and error tests a specially developed resin compound was evolved which, when reinforced with Fothergill & Harvey's Tyglas cloth, provided a ducting capable of being crushed to pass the flange through the bulkhead panel hole.

Advantages claimed for the ducting include good air flow, corrosion resistance, light weight, resistance to heat and chemicals, and durability. In addition, one of the most important faults of previous types of glass reinforced plastic ducting, i.e. brittleness, is claimed to have been overcome. Baxter, Woodhouse & Taylor Ltd., Poynton, Manchester.

EMD 6241 for further information

Heat-resisting Ni-Cr Casting Alloy

Nimocast EPE 10 is a new type of nickel-base, high-temperature alloy that has been developed specifically for air-casting. In addition to chromium it contains niobium as an essential hardening element instead of the titanium and aluminium used in previous alloys. By excluding these two latter elements completely, excellent air-casting characteristics are said to have been obtained, with complete freedom from oxide film inclusions. The niobium is present not as a carbide, but as a compound with nickel, and for this reason the carbon content must be carefully controlled. The mechanical properties are those required for exacting high-temperature service; for example, Nimocast EPE 10 is likely to prove attractive for cast turbine rotors operating at temperatures up to 850 deg. C. The International Nickel Company (Mond) Ltd., Thames House, Millbank, S.W.1.

EMD 6242 for further information

Polyfunctional Epoxy Resin

Until recently, "epoxide" (or epoxy or ethoxylene) resin has meant for practical industrial purposes only one class of resin, namely that which results from reacting epichlorhydrin with the polyhydric phenol known as bisphenol-A. Such "conventional" epoxide resin/hardener systems have proved extremely useful; there are, however, certain severe limitations to their use which industry would be glad to see removed, especially in regard to mechanical and electrical properties at higher temperatures, and resistance to chemical attack.

A new polyfunctional solid epoxide resin is claimed to show a marked improvement in thermal, electrical and chemical resistance, and to have fast moulding cycles (made possible by the resin's abnormally high reactivity). The fact that it costs no more than an ordinary bisphenol epoxide has already led to its adoption for some industrial applications, such as the matched-die moulding of glass-reinforced motor-car components, and the production—via "pre-preg"—of tubing. A notable feature of the new resin, and one which accounts for its superior performance, is that, unlike the normal solid epoxide, it has an epoxy-value at least equal to that of the best liquid bisphenol-epoxide resins. Leicester, Lovell & Co. Ltd., North Baddesley, Southampton.

EMD 6243 for further information

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EMD 6134 for further information

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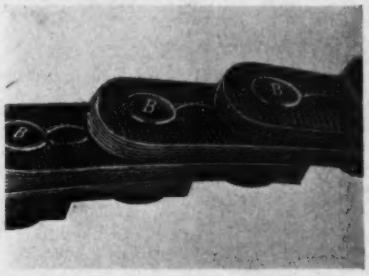
WHAT'S NEW IN MATERIALS & COMPONENTS

V-Link Belt

The recent trend of V-belt drives has been in the direction of narrower or smaller endless belts, capable of transmitting higher horse-power. V-Link belting claims as many as fourteen advantages over solid endless belts, but there were many practical difficulties in producing a link belt capable of transmitting similar loads to the premium or wedge type of endless belts.

In the new Brammer Plus link belt, the special rubber sheeting used is made from a complicated blend of cotton and man-made fibres, vulcanised with special synthetic rubber. It is claimed that this combination makes a belt which is considerably stronger in every way, and



which will transmit greater horse-power and give a longer life, apart from being heat and oil resisting. For identification purposes the belt is made in an outstanding red colour and is fitted with the usual studs marked B, which have colour variation to determine section widths. Brammer & Co. Ltd., Leeds.

EMD 6244 for further information

Miniature Thermocouple Wires

The range of Thermocoax miniature thermocouple wires has now been extended by the addition of two new and smaller sizes having outside diameters of 0·34 and 0·25 mm. respectively. The new wires are of Chromel-Alumel in stainless-steel sheaths, and are available in limited continuous lengths of up to 6 m. Type numbers are 2ABACO34 and 2ABACO25 respectively. Research & Control Instruments Ltd., 207 King's Cross Road, London, W.C.1.

EMD 6245 for further information

Gelled Primers

A substantial saving in the time and labour costs of protecting structural steelwork from corrosion is claimed for a new painting system. Thick film gelled primers, two coats of which are equal to four or five coats of conventional paints but which do not sag or "curtain" after application, were introduced in 1959 after extensive laboratory and raft exposure tests.

The Ferrogel range of gelled or thixotropic primers has now been developed for use on industrial structures. As many of such structures are subjected to severe anti-corrosive conditions, but are inaccessible except during process shut-down, the ability to apply very heavy coats of primer in a short time is obviously attractive, especially where high staging must be erected before painting. Robert MacNab & Partners, Public Relations, 22a West Nile Street, Glasgow, C.1.

EMD 6246 for further information

Oil and Grease Absorbent

There are many instances where a wet floor-cleaning process is impractical, and even on occasion, hazardous. For this reason, Attapulgite, a specially processed mineral, is being used in the U.S.A. as a simple, safe and economical means of maintaining clean floor areas where oil spillings are unavoidable. This mineral is now being imported into the U.K. for the manufacture of Dresser-Dri, which will absorb oil and grease up to one third of its own weight.

Oil-impregnated Dresser-Dri will not burn, it is claimed; fire hazards are thus reduced. This absorbent, when sprinkled over an oily floor, soaks up oil spills and can be swept up at leisure. It can be used again and again until it becomes completely saturated.

Since Dresser-Dri is a dust-free mineral absorbent, there is said to be no fear of damage to plant, equipment or components. Magnus Chemical Co. Ltd., Salisbury Road, Trading Estate, Uxbridge, Middlesex.

EMD 6247 for further information

Cushioning Material

Economy, maximum protection and low weight are the important features claimed for Texlite, which is a new pack-cushioning material of crimped rubberised hair. Although the same basic materials—curled hair bonded with a carefully compounded latex rubber—are used to make Texlite as for the company's other rubberised hair sheet, moulded and modular units, the new production technique is said to be a major break-through. Curled hair is carded into a delicate uniform layer of light density, gently gathered by a system of needles, and condensed. Not only is the original curl of the hair preserved, but a crimped structure is developed through the needling action. This is claimed to give Texlite exceptional resistance to stratification, and a resilience never before achieved in high-density rubberised hair. The Hairlok Co. Ltd., Magna Works, Kathie Road, Bedford.

EMD 6248 for further information

Contact Adhesive

Pitan Contact Adhesive No. 1 is a solution of mixed synthetic rubbers blended with a reinforcing resin. It is recommended for the fixing of plastics laminates and other laminated sheets to table tops, counters, walls, etc, and will bond rubber, plastics, wood and metal to themselves, to each other and to wall surfaces of plaster and concrete. It is light brown in colour, of medium viscosity, and is said to be resistant to oil, petrol and heat.

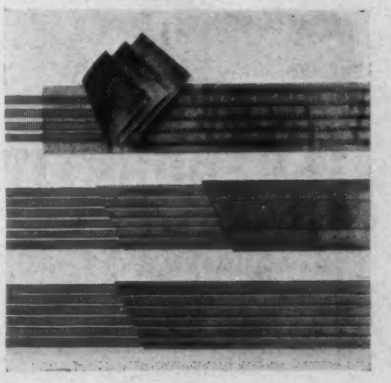
The method of application is to clean thoroughly and dry both surfaces, and apply an even film of the adhesive over each surface by means of a serrated trowel or brush. Allweather Paints Ltd., 36 Great Queen Street, W.C.2.

EMD 6249 for further information

Flat Element Heating Tapes

The special feature of Hotfoil heating tapes is their flat foil elements. A flat element must be very thin in order to have a high enough resistance, and to heat up almost instantaneously. Hence the use of metal foil, which is so treated and encased that any stresses in the tape, even with the roughest handling, are not transmitted to it. If a sudden load is applied to the tape this tends to stretch the plastics insulation, but there is no danger of this affecting the elements themselves, as a patented corrugating system provides them with elasticity which allows very much more stretch to take place safely in the element than ever occurs in the insulation surroundings. The result is greater security in the strength of the elements. Another important characteristic is that the sealed plastics construction makes them moisture proof.

The combination of foil elements and simple plastics insulation gives the tapes

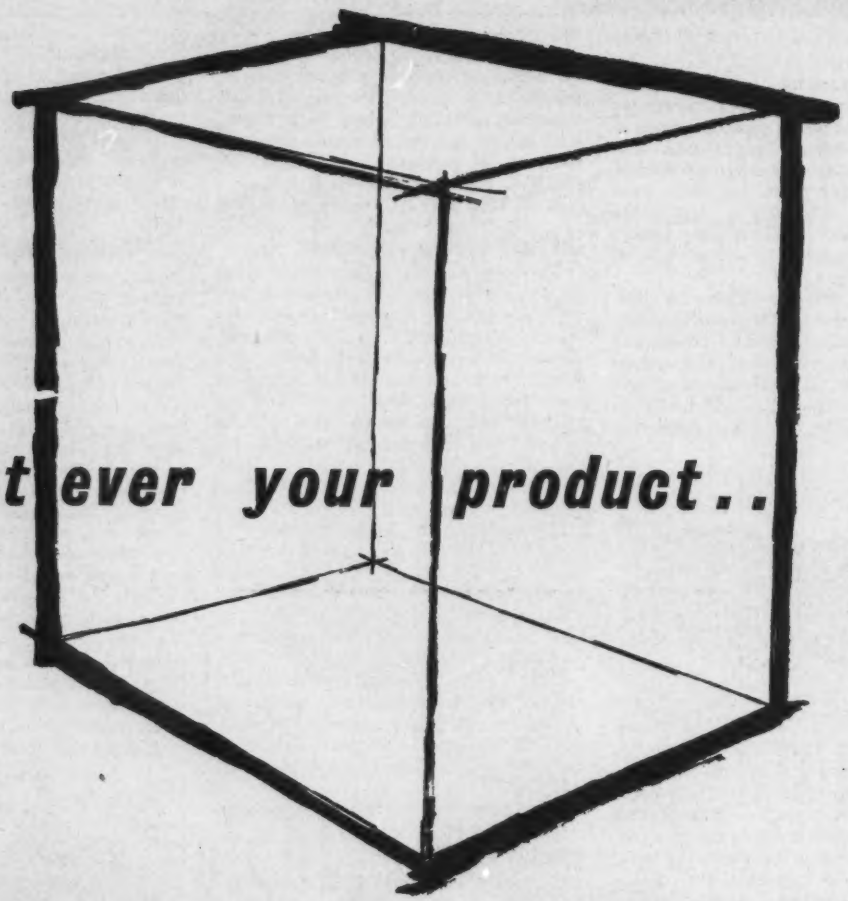


good flexibility and space-saving qualities, as well as adequate mechanical strength for many jobs. For heavy industrial use, however, a very strong woven fibreglass cladding is provided on the outside of the plastic sheath. This results in a slight increase in thickness but virtually no loss in flexibility, as the tape can still be wrapped round a ¼-in. pipe.

The plastics insulation is limited to a maximum temperature of the heated object of 110 deg. C. Therefore, for higher temperatures the manufacturers have designed and patented an all-glass system of construction and insulation. The same corrugated element is employed, but the sewn-glass construction of the tape makes it suitable for heating objects to temperatures in the region of 450 deg. C. The M.E.I. Co. Ltd., Cyprus Works, Upper Villiers Street, Wolverhampton.

EMD 6250 for further information

EMD 6135 for further information



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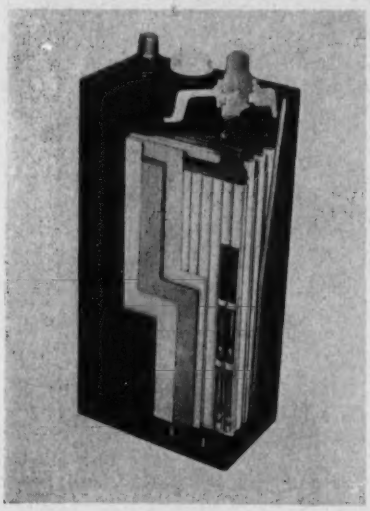
WHAT'S NEW IN COMPONENTS

High-capacity Tubular Batteries

High-capacity tubular batteries have recently been introduced as complementary to the standard specially-armoured ranges. These batteries, which are claimed to give from 32 to 38 per cent increase in capacity over the standard types, have been designed for use where circum-



stances call for either high capacity or reduced physical size.

The current is carried by vertical spines which are cast integrally with the top connecting bar in a special lead alloy, the active material being held in close contact with these spines by finely-woven fabric tubes. The material from which these tubes are woven is a synthetic fibre, completely immune from attack by sulphuric acid and oxidisation. Its very fine weave reduces any loss of active material to a minimum and, moreover, it has a high porosity which enables the standard of performance to be maintained even at the highest rate of discharge.

An additional feature is the use of a conducting lead alloy base plug. Besides sealing the bottom ends of the tubes, this connects the spines electrically, and thus provides an alternative current path if a spine should fracture towards the end of the life of the battery.

Armouring of the negative plate completes the advance which armouring of the positive plate began. Thus enclosed, it is said to be impossible for material which may eventually be shed by the plates to accumulate and cause side and bottom shorts. The low-resistance microporous sheets forming the armouring also act as separators. There are thus no loose separators in the battery. Crompton Parkinson Ltd, Crompton House, Aldwych, London, W.C.2.

EMD 6251 for further information

New Control Relay

Class 7001 Type D industrial control relay is a compact, 10-A. maximum 250-V., d.c.-operated relay, the contacts of which can be used to switch a.c. or d.c. supplies. It is manufactured in three basic types, providing up to four, six and ten contacts respectively. All relays have identical mounting dimensions, and can be disassembled whilst in situation, from the front.

Although small in physical size, the units are said to have an overall construction that is exceptionally robust, for long, trouble-free mechanical and electrical life. Operating coils are available for voltages up to 250 V., d.c., and are encapsulated in an epoxy resin moulding which gives protection against mechanical damage and moisture absorption.

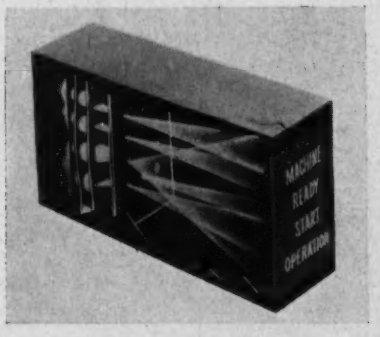
Also newly available for use with these relays is a mechanical latching attachment, designated Class 7008, Type M1, to convert relays from electrically held to mechanically held. This attachment has identical mounting holes to the relay, thus permitting easy conversion from one type to another after installation, without increase in mounting area. Square D Ltd., Cheney Manor, Swindon, Wilts.

EMD 6252 for further information

Rear Projection Digital Display

An improved digital display, which will display words backlighted with colour, is announced. Red, orange, yellow, green or blue colours may be displayed on the screen either by themselves or as a background for the word messages. The desired colour is selected by the user.

Known as the series 80,000 digital display, the unit contains a master condensing lens with twelve individual positions or lenses. On each lens is printed the desired word, message or colour. When one of the twelve lamps at the rear of



the unit is lighted, the lamp projects the correspnding word or colour on to the viewing screen at the front of the unit.

The unit has an aluminium case, is $3\frac{9}{32}$ in. wide, $5\frac{1}{4}$ in. high and $11\frac{13}{16}$ in. long, and weighs $3\frac{1}{4}$ lb. Counting Instruments Ltd., 5 Elstree Way, Boreham Wood, Herts.

EMD 6253 for further information

Ceramic Electroluminescent Devices

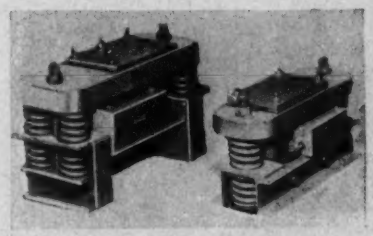
Electroluminescent cells containing organic media are much more susceptible to electrical breakdown during life due to the ingress of moisture than are those containing only inorganic materials. The latter type are often referred to as "ceramic electroluminescent lamps". In this latter construction the phosphor is embedded in a ceramic layer similar to that used in vitreous enamelling processes applied to a metal or a conducting glass plate. The second conducting layer or electrode is formed as a nearly invisible film on the phosphor layer, and finally another enamelled layer seals and insulates the construction.

Previously, this type of ceramic construction was used at lower frequencies and voltages (usually mains supplies) than the organic type of electroluminescent lamp. Recent progress in the formulation of the enamels (e.g. British Patent Application No. 10735/60) and methods of construction have substantially increased both the brightness of ceramic electroluminescent lamps and also the voltages and frequencies at which they can be operated. Ceramic electroluminescent lamps can now be made at least as bright as the earlier organic type of construction, and with the advantage of a very much longer operating life. Thorn Electrical Industries Ltd., Great Cambridge Road, Enfield, Middlesex.

EMD 6254 for further information

High Efficiency Magnetic Vibrators

By reversing the static to fixed weight ratio of a new range of vibrators, Magco Ltd. claim that they have achieved a considerable increase in efficiency and a



reduction in production costs. In the new design the bottom unit, which carries the armature, is comparatively light, while the upper moving unit consists of a casting on which is carried the laminations and coil. The new range of vibrators have many uses, the most common of which is where a difficult or damp material will not flow freely forward out of a hopper.

A complete range of sizes is available. The smaller units operate twice per cycle, and give 6,000 vibrations per min. on a 50-c/s supply, or 7,200 per min. on a 60-c/s supply. The larger models operate on a half wave system, and give 3,000 vibrations on a 50-c/s supply and 3,600 on a 60-c/s supply. Magco Ltd., Lake Works, Portchester, Hants.

EMD 6255 for further information

Please Note!

We receive many reader enquiry cards on which the reader has omitted to fill in his name and address. In order to avoid disappointment we remind readers that names and addresses should be included on each card.

WHAT'S NEW IN COMPONENTS

High-vacuum Seals

Nygon is a trade name for a material specially prepared for high-vacuum sealing. Made in the shape of "O" rings, and in sheet form, it covers the whole range of high-vacuum requirements at normal temperatures. It has a shore hardness of about 50° with a highly polished surface, and is black in colour. Low volatility ingredients have been incorporated to prevent vaporisation at high vacua.

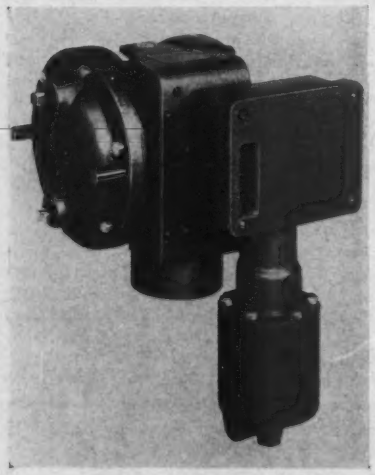
Nygon is said to have a compression set of less than 7 per cent, and a permanent set of less than 2½ per cent. All the seals are designed to operate under a compression of about 30 per cent; this ensures a vacuum-tight seal. Due to the low compression set, it is claimed that "O" rings may be used over and over again with absolute safety. N.G.N. Electrical Ltd., Avenue Parade, Accrington, Lancashire.

EMD 6256 for further information

Flow Transmitter with Local Indication

The model 11A flow transmitter is designed to measure the differential pressure on a liquid passing through an orifice and to transmit a high-volume pneumatic signal (3-15 p.s.i.) directly proportional to the input. A mechanically-linked local indicator is claimed to give a true indication of differential pressure or flow, and to be completely independent of air supply.

Suitable for direct connection to an orifice without, in most cases, the use of sealing fluid and pots, the instrument can also be used without additional equipment for measuring and indicating liquid level, interface level, specific gravity and many other process variables which can be ex-



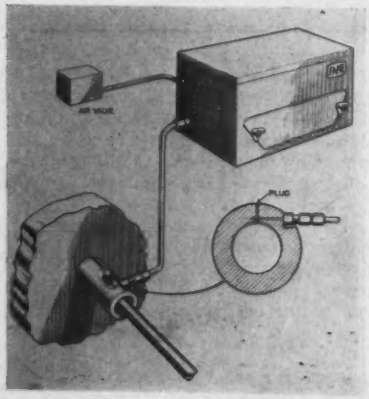
pressed in terms of a differential pressure. Where required, for flow applications, square root extraction can be performed by use of the model 76 relay.

Standard ranges are 0-25, 0-50, 0-100, 0-150, 0-200, 0-300 and 0-400 1 in. w.g. differential. Ranges up to 50 p.s.i. are available, and also centre zero ranges and positive and negative suppression. Air consumption is not more than 0·12 s.c.f.m. (dead end service in balance), and a change in supply of up to 5 p.s.i. does not change the output by more than 0·1 p.s.i. Associated Electrical Industries Ltd., Crown House, Aldwych, London, W.C.2.

EMD 6257 for further information

Automatic Lubricant Injector

An automatic lubricant injector is announced which is claimed to solve the problem of plunger lubrication in pressure die-casting machines, where the use of heavy lubes is generally considered essential. The injector is a two-stage unit capable of dispensing heavy graphite-bearing compounds. The first stage draws the lubricant from a supply tank and pumps it to the second stage at a pressure of about 200 p.s.i. From the second stage the lubricant is pumped at pressures up to 1,500 p.s.i. and in quantities from 0·045 to less than 0·005 cu. in. The quantity is



controlled with steel distance pieces which limit the intake of lubricant. The pumping system has a fully scavenging action which ensures that the right measure is delivered every time and prevents build-up within the system.

On a pressure die-casting machine, an injection is made after every cast to ensure consistent but not excessive lubrication. The efficiency of the lubrication introduces an economy in lube and reduces wear on both plunger and sleeve.

The unit operates from a compressed air supply of 60 to 150 p.s.i., and can be controlled by an air pilot, a solenoid or a mechanical roller valve. It can be fitted to existing machines. The accompanying diagram shows the general arrangement of an installation. Foundry & Metallurgical Equipment Co. Ltd., Netherby, Queens Road, Weybridge, Surrey.

EMD 6258 for further information

New Filters

A new range of single- and double-chamber filter units has been developed, designed to remove solids in suspension from liquids such as fuel oils, diesel oils, petrol, quench oils, hydraulic oils, edible oils, glycerine, aviation fuels, coal tar liquids, crude benzol, and from water, water solutions and sea water when used as coolant circulants. The single-chamber unit (illustrated) will be known as the Uniplex filter, the double-chamber unit as the Biplex filter.

The Biplex filters are designed for continuous operation. By means of a cen-

trally located and manually operated control valve, the flow of liquid can be switched from one chamber to the other. There is no interruption of the flow of liquid when it is necessary to remove a filter basket for cleaning. The valve is so designed that it is impossible, even accidentally, simultaneously to shut off the flow from both chambers.

Both filters are designed to operate at temperatures up to 120 deg. C. and at pressures up to 150 p.s.i. Zwicky Ltd., Buckingham Avenue, Slough, Bucks.

EMD 6259 for further information

Liquid Feeder

The Tolu feeder is used for feeding liquids of various kinds under pressure, and is available in single or double units, the capacity of each unit being from ¼ to 7 gall./hr. The flow can be varied within close limits while the pump is running, and each unit is entirely independent. Plastics housings and stainless-steel parts are standard, but other materials are available for special applications. Neldco Processes Ltd., Crossway House, Bracknell, Berks.

EMD 6260 for further information

Electro-magnetic Valves

A large range of electro-magnetic valves, manufactured by Concordia G.m.b.H., Stuttgart, is now available in the U.K. The range includes: single-way electro-magnetic valves for air, water and non-corrosive gases, and liquids up to a viscosity of 6° Engler (184 Redwood at 70 deg. F.); single-way electro-magnetic valves for low gas pressures; single-way electro-magnetic valves for steam; single-way electro-magnetic valves for fast and/or frequent operation; three- and four-way electro-magnetic valves for compressed air and hydraulic fluids; pressure switches; and an electro-magnetic valve which will close a rubber tube carrying liquid or gas at low pressures up to 10 lb. Londex Ltd., Anerley Works, S.E.20.

EMD 6261 for further information

WHAT'S NEW IN EQUIPMENT

Rectilinear Recorder

This recorder is now being offered as a universal instrument, in that an extremely wide range of paper speeds will be available, and any number of channels up to a present maximum of twelve can be fitted. This latter advantage has been made possible by constructing each channel as a complete magnet system and galvanometer movement. The outstanding feature of this instrument is the choice of either a curvilinear or rectilinear trace. The rectilinear trace is produced by running the paper over a knife edge and fitting the pen with a writing element. Electro-sensitive and heat-sensitive papers also can be used in this instrument.

The gearbox is provided with an electrical gear change which is actuated by means of press buttons, thus making possible remote control of the recorder. Other features claimed are: excellent viewing angle of the recorded trace; simple paper replacement from the front of the recorder; ready adaptability of the unit to accept different types of galvanometers and widths of paper; and simplicity of construction. Kelvin & Hughes Ltd., Livingstone College, Knotts Green, London, E.10.

EMD 6262 for further information

Tractor-mounted Air Compressors

A new range of tractor-mounted air compressors, type Nos. 80IT, 100IT and 125NT, has been designed to provide air power at short notice when and where it is needed. The units are of the two-stage single-acting piston type with intercooler, and are simple to operate. One does not have to be a skilled mechanic to maintain them. They are intended for mounting on a tractor's three-point hydraulic linkage, the connecting points to the tractor drawbars being adjustable. Mounting or dismounting can be carried out in a few minutes. A splined propeller shaft for connection to the tractor's power take-off is provided.

A typical use for these air compressors is where roads have to be cut through rough ground. For this work drilling is necessary, and to power the rock drills the combination of tractor and compressor has been found ideal. The comparatively low weight of the compressor maintains the good balance of the tractor.

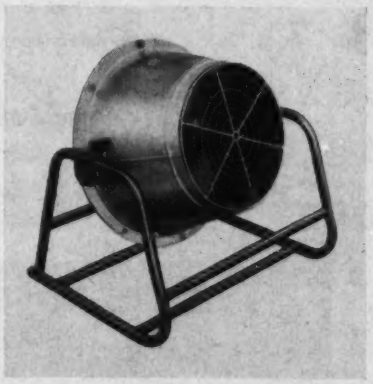
Compressors type 100IT and 125NT can be had with two different gear ratios to give alternative speeds. In all three machines the air receiver forms the main part of the frame. Atlas Copco (Great Britain) Ltd., Maylands Avenue, Hemel Hempstead, Herts.

EMD 6263 for further information

Cooler Fans

The transportable Man Cooler fans are primarily designed to provide immediate relief to operators working in foundries or in close proximity to furnaces and steam raising plants. They project a stream of cooling air where it is most required, and because of their mobility they can be quickly positioned in various locations.

The fans are fitted with high-efficiency axial flow type impellers of cast aluminium alloy, and are powered by amply rated totally enclosed motors to British Standard Specification. Aperture



diameters of 22 and 18 in. are available, both tripod and cradle mounted to suit the particular requirement. W. G. Cannon & Sons Ltd., 38a St. George's Drive, London, S.W.1.

EMD 6264 for further information

Portable Finish-boring Machine

The F.M. coupling fine boring machine is specifically designed for finish-boring holes in coupling flanges, and is ideally suited to applications where a restricted space of only 22 in. is available, even less space being required for narrower flanges. Tapered diameters of the coupling shaft do not affect the mounting of the machine, since it is clamped to the periphery of the flange itself.

The boring bar runs in high-precision combined thrust and needle roller bearings, housed in steady brackets located at each side of the flange, thus ensuring maximum rigidity. The tungsten carbide cutter is set to size by a special micrometer which is supplied with the machine, and cutter sharpening is carried out on a built-in metal bonded diamond wheel, using jigs to ensure correct cutting angles.

Stepped V pulleys give a range of three speeds and automatic feed is provided.

The standard machine is designed to bore parallel holes only, and is supplied with a plain cylindrical boring bar. A taper boring unit is available as an optional extra, and can be installed in the machine without any modification. Buma Engineering Co. Ltd., Robson Street, Newcastle upon Tyne, 6.

EMD 6265 for further information

Conveyorised Automatic Spraying Machine

The Bullows conveyorised automatic spraying machine consists of a conveyor track; a spraying station comprising one spray gun; a gun traverse motion and brackets, and a down-draught exhaust system. Apart from the air required for spraying purposes, power is provided by two electric motors. The length of spraying time is infinitely variable by means of adjustable cams. Compressed air at 60 p.s.i. is required to operate the spray guns and valves.

Dependent upon the rate of production required and the type of article to be sprayed, the unit can be fitted with a 2-, 3-, 4- or 6-in. pitch chain into which workholders fit, and as standard has approximately 25 ft. of chain. The conveyor is in constant motion, and guns, when spraying, follow the work targets. This reduces inertia problems and greatly simplifies the mechanism, entirely eliminating chain make-up devices. Automatic spray guns are rigidly mounted on the gun cylinder arms, which are hydraulically powered via gearbox-operated master cylinders. If it is required to change to articles of varying sizes, adjustment is quickly and easily effected by interchanging or adjusting cam settings to cover gun motion and spraying time.

The down-draught exhaust system is ducted vertically through the centre of the machine, opposite the spraying station. Paint-laden air is carried down to an easily removed castor-mounted separator which incorporates an effective system of circular baffles, and the exhaust air is then taken up and out to atmosphere. A mechanical memory device is available as an optional extra. This automatically signals the machine when workholders are loaded or not, and thus provides a flame-proof paint-saving device, also preventing unloaded workholders from being painted. Alfred Bullows & Sons Ltd., Long Street, Walsall, Staffs.

EMD 6266 for further information

EMD 6136 for further information

THIS IS NOTHING TO WHAT GOES ON INSIDE A BULLOWS NOPUMP SPRAY BOOTH

ALMOST ENTIRELY ELIMINATES MAINTENANCE

NO PUMP
NO FILTERS
NO PIPES
NO NOZZLES

In this new type of Water-Wash Spray Booth the exhaust air travels at very high velocity over the water surface entraining water. The air/water mixture, moving through controlled changes of direction, provides the scrubbing action.

★ **A NEW PATENTED PROCESS OF WATER TREATMENT...** **substantially increases the efficiency of these Booths.**

NO CLEANING OUT AFTER 1 YEAR'S CONTINUOUS DOUBLE-SHIFT WORK AT

Massey-Ferguson
(UNITED KINGDOM) LTD.

STRETFORD · MANCHESTER

This Booth was started up on production on 1st March, 1959, and has operated two nine-hour shifts on continuous painting of agricultural machinery. When last examined, there was an average depth of silt of 6 inches over the entire water tank bottom, an area of 290 sq. feet. A further 4 inches, making 10 inches in all, can be accommodated before cleaning is essential. After 1 year's operation, the fan and ducting were barely discoloured, the only maintenance cost being cleaning the floor inside the booth, routine greasing of bearings and similar preventive maintenance.

VISITS TO FACTORIES WHERE BULLOWS' NOPUMP SPRAY BOOTHS HAVE BEEN INSTALLED CAN BE ARRANGED ON REQUEST. WRITE TODAY FOR FULL DETAILS OF THIS OUTSTANDING BULLOWS' ACHIEVEMENT.

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WHAT'S NEW IN THE OFFICE

D. O. Equipment

Three new products of interest to draughtsmen have recently been introduced.

The Elite system for small drawings is designed specifically for sheets of 20 × 15 in. It provides space for 6,000 drawings in a cabinet 2 ft. 6 in. × 2 ft., with easy access.

The Elite system for draughting is based on the combined draughting and reference table principle, and is suitable for either a drafting machine or straightedge. It is streamlined and modern in appearance, with a formica table top.

The Elite magnetic planning board, available in various models, has a safe magnetic system, and the space-saving feature of being able to provide 100 horizontal lines in 25¼ in. M.B.C. (Office Systems) Ltd., 31 Crouch Street, Colchester. **EMD 6267** for further information

Slide Rule for Pipes

A "pipe weights and strengths" slide rule has recently been introduced. This highly accurate instrument gives answers —simultaneously in British, U.S.A. and metric units—to three commonly occurring sets of calculations which normally would take a considerable time to work out.

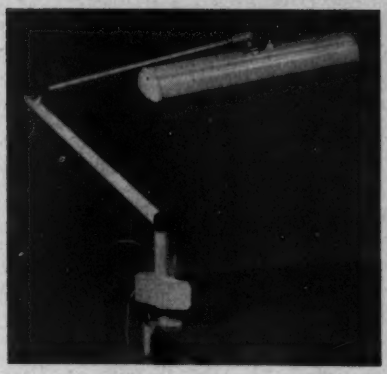
One operation gives the weight of steel, aluminium, cast or spun iron, bronze, copper or lead pipes when the diameter and thickness are known. A second operation enables the user to determine the value of either the bursting, test or working pressure; the yield or stress point of material required; or the o.d. or thickness of any metal pipe when the other three values are known. Finally, a set of scales gives the relative carrying capacities of pipes of different internal diameters. It is also possible to use the rule for straightforward price calculations. Blundell Rules Ltd., Regulus Works, Lynch Lane, Weymouth, Dorset.

EMD 6268 for further information

Swedish Desk Lamps

Two lamps which operate on a counterbalance principle have recently been introduced into the U.K. from Sweden. They are made by Cebe of the A.S.E.A. group.

The Cebe I uses a tungsten filament lamp with a round reflector. A noteworthy feature is the concealed compression spring system. The springs are of massive



proportions and can be adjusted by screws on the underside of the die-cast base housings. The lamp is supplied with a three-core cable, and is available in several colours. Suitable base clamps are available for use on a wall, or for mounting on a desk or table.

The Cebe II (illustrated) uses two 18-in. fluorescent tubes, with a total rating of 30 W., which are said to give about the same light output as a 100-W. tungsten lamp. This lamp has a reach of 40 in., and is available in several colours. It is provided with a built-in ballast situated in the base of the pillar. M. J. Glover & Co. Ltd., 8 Evelyn Grove, London, W.5.

EMD 6269 for further information

New Publications and Technical Literature

Johnson, Matthey & Co. Ltd.: 29-page illustrated booklet of data on the firm's electrical contacts. 73-83 Hatton Garden, London, E.C.1.

EMD 6270

Imperial Chemical Industries Ltd.: Proceedings of a symposium on "Titanium Production Methods in the Aircraft Industry", held at the I.C.I. Titanium Plant, Waumarlwydd, 1960; contains twelve papers and report of discussions. Metals Division, P.O. Box 216, Kynoch Works, Witton, Birmingham, 6.

EMD 6271

The British Oxygen Co. Ltd.: 45-page booklet of welding procedure and data. Quasi-Arc Works, Bilston, Staffs.

EMD 6272

Ferodo Ltd.: "Friction Materials for Engineering Equipment", a 270-page catalogue consisting of a separate illustrated introduction, data book and price list, bound together in a semi-stiff cover. Chapel-en-le-Frith, Stockport.

EMD 6273

Imperial Aluminium Co. Ltd.: Two catalogues giving comprehensive details of Impalco aluminium and aluminium alloy extrusions—volume 1 (130 pages) describes the complete range available, and volume 2 (38) gives a selection of the shapes for which dies are held. Imperial Chemical Industries Ltd., P.O. Box 19, Templar House, 81-87 High Holborn, London, W.C.1.

EMD 6274

Simmonds Aerocessories Ltd.: "Spire Speed Nuts", an 84-page well-illustrated manual of data which includes all the recent developments in the company's range of spring steel fastenings. 7 Cleveland Row, London, S.W.1.

EMD 6275

Timber Development Association: "Design in Timber", a well-illustrated 25-page brochure describing the facilities provided for designers by the Association and the timber industry in collaboration with the Department of Scientific and Industrial Research. 21 College Hill, London, E.C.4.

EMD 6276

The United Steels Companies Ltd.: "This is United Steel", an illustrated book of the firm's activities in mining, iron and steel founding and manufacture—includes aspects of research, personnel and commercial activities. P.O. Box 64, The Mount, Broomhill, Sheffield.

EMD 6277

Johnson, Matthey & Co. Ltd.: Revised edition of data sheet 1300:331, giving details of a change in the recommended heat-treatment of Mallory 73 beryllium copper. 73-83 Hatton Garden, London, E.C.1.

EMD 6278

The Geigy Co. Ltd.: "Chemicals for Metal Treatment", a 20-page catalogue showing the various applications of the firm's products. Rhodes, Middleton, Manchester.

EMD 6279

The North British Steel Foundry Ltd.: "A Steel Foundry Service", a booklet describing the company's resources—also contains a steel selection guide, and a summary of chemical compositions and mechanical test requirements covering some thirty-one steels. Bathgate, Scotland.

EMD 6280

Henry Wiggin & Co. Ltd.: "Machining Wiggin High-nickel Alloys," 68-page illustrated booklet describing current practice in the machining of nickel-base alloys. Wiggin Street, Birmingham, 16.

EMD 6281

Bonded Bearings Ltd.: 12-page brochure giving a general introduction to the ZSV process of applying resin-bonded antifriction layers to a metal surface. Station Road, Langley, Bucks.

EMD 6282

Imperial Chemical Industries Ltd.: 47-page brochure on I.C.I. rods and sections in copper and copper alloys. P.O. Box 19, Templar House, 81-87 High Holborn, London, W.C.1.

EMD 6283

Hadfields Ltd.: "Die Steels", a brochure (No. 550) setting out the factors affecting die steel selection, and giving brief details of the company's range. East Hecla Works, Sheffield, 9.

EMD 6284

English Electric Valve Co. Ltd.: 38-page quick-reference booklet of abridged data on the firm's range of valves. Chelmsford.

EMD 6285

SHEET

STRIP

PLATE

EXTRUDED SECTIONS

ROD AND BAR

TUBE

FORGINGS

CORROSION - RESISTING ALUMINIUM ALLOYS

Birmabright

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BIRMABRIGHT LIMITED

WOODGATE WORKS, BIRMINGHAM 32

News of Industry

An international research laboratory to study corrosion of metals will shortly be built in South Africa by **Plastic Protection (Pty.) Ltd.**, a member of Engelhard Industries, of South Africa. The laboratory will investigate the unusually large number of natural corrosive phenomena found in the Union.

The European Atomic Energy Community (Euratom), the **United Kingdom Atomic Energy Authority** and the **United States Atomic Energy Commission** have set up a central information office, Transatom, at Euratom's Brussels headquarters. A monthly *Transatom Bulletin* is to be published which will list existing translations recently reported to the Brussels office, as well as new translations planned by international or national institutions and private firms in the European Community, the U.S.A., the U.K. and other countries. The bulletin is available on a subscription basis from: Transatom, 51 rue Belliard, Brussels, Belgium.

All data relating to translations, including those made before the establishment of Transatom, are being collected and recorded in a master file system at Brussels. Copies of this card file have been offered to appropriate institutions in countries with interest in the nuclear field.

The 20,000-ton M.V. *Amazon*, a recent addition to the Royal Mail Lines' fleet, is the first of three new ships propelled by two single-acting **Harland** B & W cylinder pressure induction engines of the latest opposed-piston design, at a service speed of 17½ knots. The cargo handling equipment includes two 15-ton, four 10-ton, two 7-ton and twelve 5-ton tubular steel derricks, and twenty electric cargo winches.

The electrical installation has aroused particular interest, since this is the first British passenger liner to use alternating current throughout. Four main diesel-driven generators supply power at 450 V., 60 c/s, three phase, controlled and distributed through a main switchboard in the engine room. Each alternator has a separate control panel, and the switchboard is fitted with protective and fault-detecting devices.

All electric motors, other than fractional horse-power types, are fed at the main distribution voltage of 440 V., 60 c/s, three phase. The lighting and small motor requirements are supplied at 230 V, 60 c/s, single phase from transformer banks, thus permitting the use of standard lamps and other equipment which can be operated off the shore mains when in port.

Large quantities of single- and multi-core butyl rubber-insulated p.v.c. sheathed cables, manufactured by **British Insulated Callender's Cables Ltd.**, were installed in the *Amazon*'s electrical circuits, and ranged in size from 127/103-in. single core and 91/103-in. three core, to 3/029-in. single core. This type of cable combines the desirable features of both varnished cambric and vulcanised rubber cables. Butyl rubber withstands oxidation and ageing to a much greater degree than vulcanised rubber, and can therefore operate at higher temperatures. In addition, butyl insulation does not require any special sealing against moisture at terminations, as does varnished cambric. The *Amazon* was built in Belfast by **Harland & Wolff Ltd.**

The American publication *Design Engineering* has recently issued, to subscribers only, a Materials Selector issue which includes a directory of American manufacturers, and also sets out the properties and available forms and applications of various ferrous and non-ferrous metals and non-metals. In addition, tables giving comparisons of materials, together with radiation effects, are included.

The basic units of the turbo-propeller power plants recently announced by **Rover Gas Turbines Ltd.** are the company's own industrial gas turbine engines (60 and 90 b.h.p. output). These engines can be used as conversion power units for existing light aircraft without large air-

frame modifications, and they are claimed to be the most compact small turbo-props in present-day production. These power plants operate on kerosene or diesel fuel, or any other light liquid distillate.

Hawker Siddeley Brush Turbines Ltd. have brought together under one roof manufacturing and test facilities for the following kinds of bladed machines: steam turbines of both axial and radial flow (Ljunström), for outputs of up to approximately 30,000 kW.; gas expansion turbines, for use with free piston gasifiers in the range 1,000-15,000 b.h.p.; gas turbines of the open cycle regenerative or non-regenerative type in the range 8,700-9,300 b.h.p. (available for electrical power generation, and for compressor, pump or other mechanical drive); turbo-chargers for diesel engines, covering diesel engine outputs of 300-5,000 b.h.p., and suitable for either industrial or marine application; and large air and gas compressors.

Where electrical load testing is required, test facilities permit loading up to approximately 5,000 kW. Two test beds are provided for the gas combustion turbines, each bed being capable of testing machinery to 10,000 b.h.p. For the gas expansion turbines, four Sigma/Pescara type gasifiers, each producing an effective 1,000 h.p., are available.

A wide range of mechanical testing and laboratory equipment for vibration analysis, noise investigation, fatigue testing, metallurgy, dynamic balancing, etc., is installed, with extensive workshops containing modern machine tools.

The **Hawker** 1127 is the first jet-sustained v.t.o.l. (vertical take-off and landing) machine in the world to be designed for operational service, and its **Bristol Siddeley** BS 53 engine is the first jet engine in which the total thrust can be directed downward for lift, backward for thrust, forward for braking in flight or in any intermediate direction. This is achieved by using movable jet nozzles. This engine is applicable to both single- and multi-engined v.t.o.l. aircraft, and also for subsonic or supersonic flight. As a ducted fan engine, the BS 53 has a better specific fuel consumption and take-off performance than a pure jet of equal cruising power.

Although Class E insulation has been used on their induction motors for some considerable time, **Parvalux Ltd.** now announce the use of this insulation throughout their complete range. In some instances it is now possible to increase output without change in frame size. Advantage of this factor has been taken in respect of the induction gear units which, when fitted with bronze gears and ball-bearing gearboxes, can be offered with a 50 per cent increase in torque over the standard units, with very little increase in price. Constant research is taking place in the development department, and it is anticipated that the range will shortly be extended with new and larger types of geared units to give increased outputs.

MEETINGS AND EXHIBITIONS

The Second International Conference organised by the **Institute of Materials Handling** is to take place in Southport from May 10-12, 1961. The Conference will provide a forum for the international exchange of knowledge and experience, and an opportunity to discuss new methods and trends for the future. Brochures may be obtained from: Institute of Materials Handling, 32 Watling Street, London, E.C.4 (CIT 7046).

EMD 6138 for further information ,

VISIT STAND No. 5BB
Engineering, Marine, Welding and Nuclear Energy Exhibition
20th April - 4th May
Empire Hall, Olympia

Workshop angle and D.O. viewpoint

Now that machining costs are so high, the legibility of working drawings has become of supreme importance. ILFORD Azoflex photoprinting papers give maximum legibility combined with speed of production and long life in normal storage and use. That is the workshop angle combined with the viewpoints of the drawing stores and D.O.

More specifically, the D.O. is interested in the Azoflex dyeline process because no ducting or darkrooms are necessary ; the process is dry, there are no fumes or excessive heat generated.

An economical and time-saving feature is that the correctness of exposure/machine speed can be gauged and adjusted immediately, even in the largest Azoflex models, because the Azoflex copy emerges fully processed in seconds and within view and easy reach of the operator. Inexperienced staff quickly grasp the simple details of Azoflex machine operation.

Photograph by courtesy of Duraglass Limited

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Your company might benefit . . .

Many business and industrial concerns find that it pays to hire certain AZOFLEX machines — rather than buy them outright. Enquiries will be treated with the utmost discretion, and will not commit you in any way.

Photoprinting Papers and Machines

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